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(54) **SYSTEMS AND METHODS FOR COORDINATING SENSOR OPERATION FOR COLLISION DETECTION**

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(51) **Int. Cl.**
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G08G 1/16 (2006.01)

(52) **U.S. Cl.**
CPC ***G08G 1/161*** (2013.01); ***G08G 1/166*** (2013.01)

(58) **Field of Classification Search**
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USPC 340/901, 902, 903, 904, 945, 961, 436, 340/3.41; 701/300, 301, 302; 342/368, 372, 342/42, 59
See application file for complete search history.

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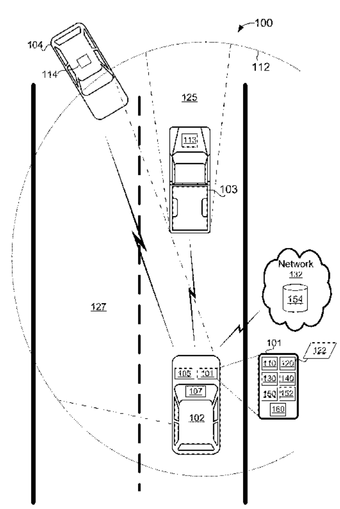
Primary Examiner — Travis Hunnings

(57) **ABSTRACT**

A collision detection system of a land vehicle may be configured to coordinate sensor operation with one or more other sensing systems of one or more other land vehicles. The coordination may comprise configuring the other sensing systems. In some embodiments, the coordination comprises forming a multistatic sensor comprising one or more emitters and/or one or more receivers. The collision detection system may be configured to receive detection signal(s) emitted by one or more of the other sensing systems. The coordination may further comprise directing detection signals of the multistatic sensor. The collision detection system may use sensor data acquired by use of the coordinated sensing system(s) to generate a collision detection model.

41 Claims, 15 Drawing Sheets



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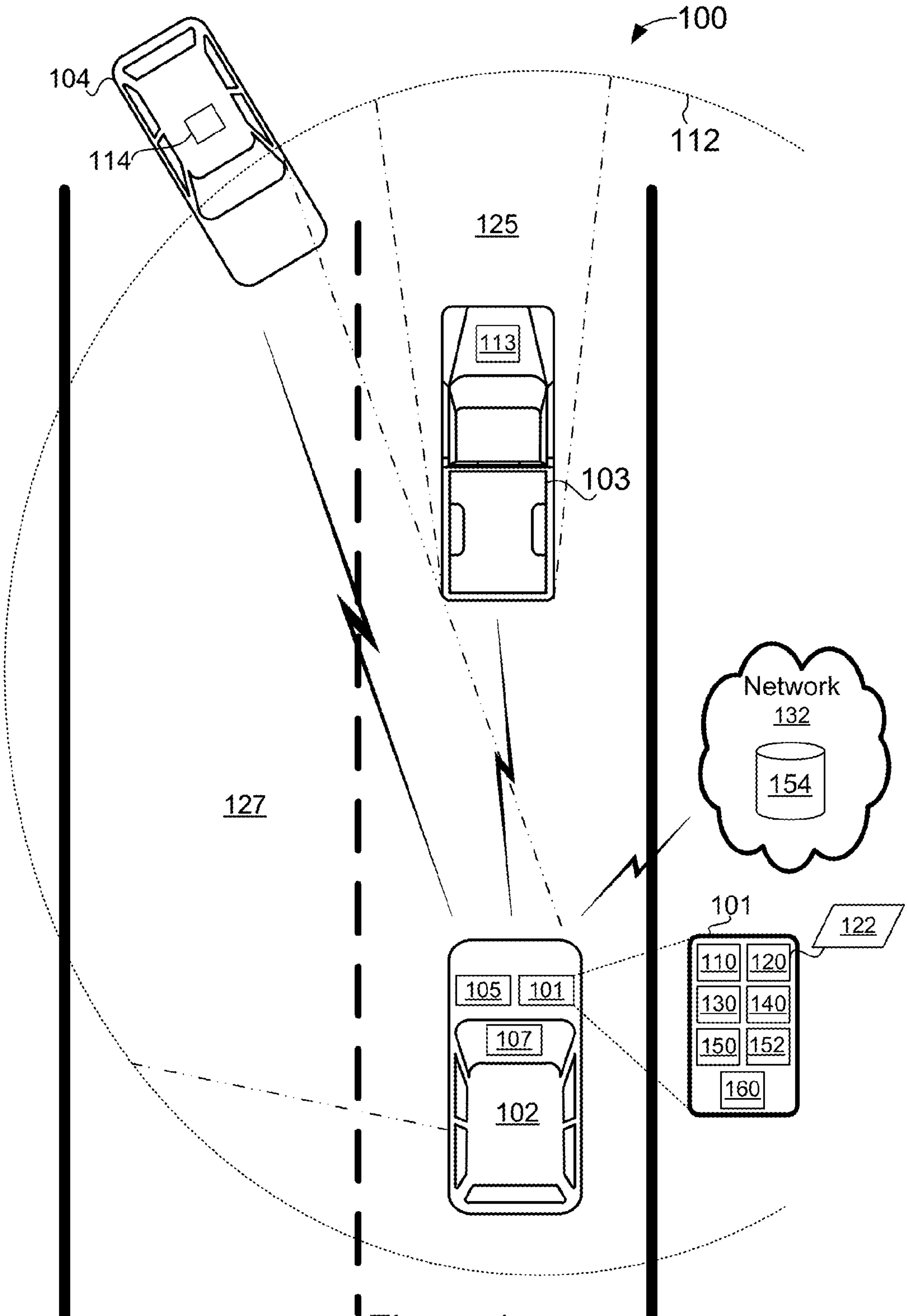
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Figure 1

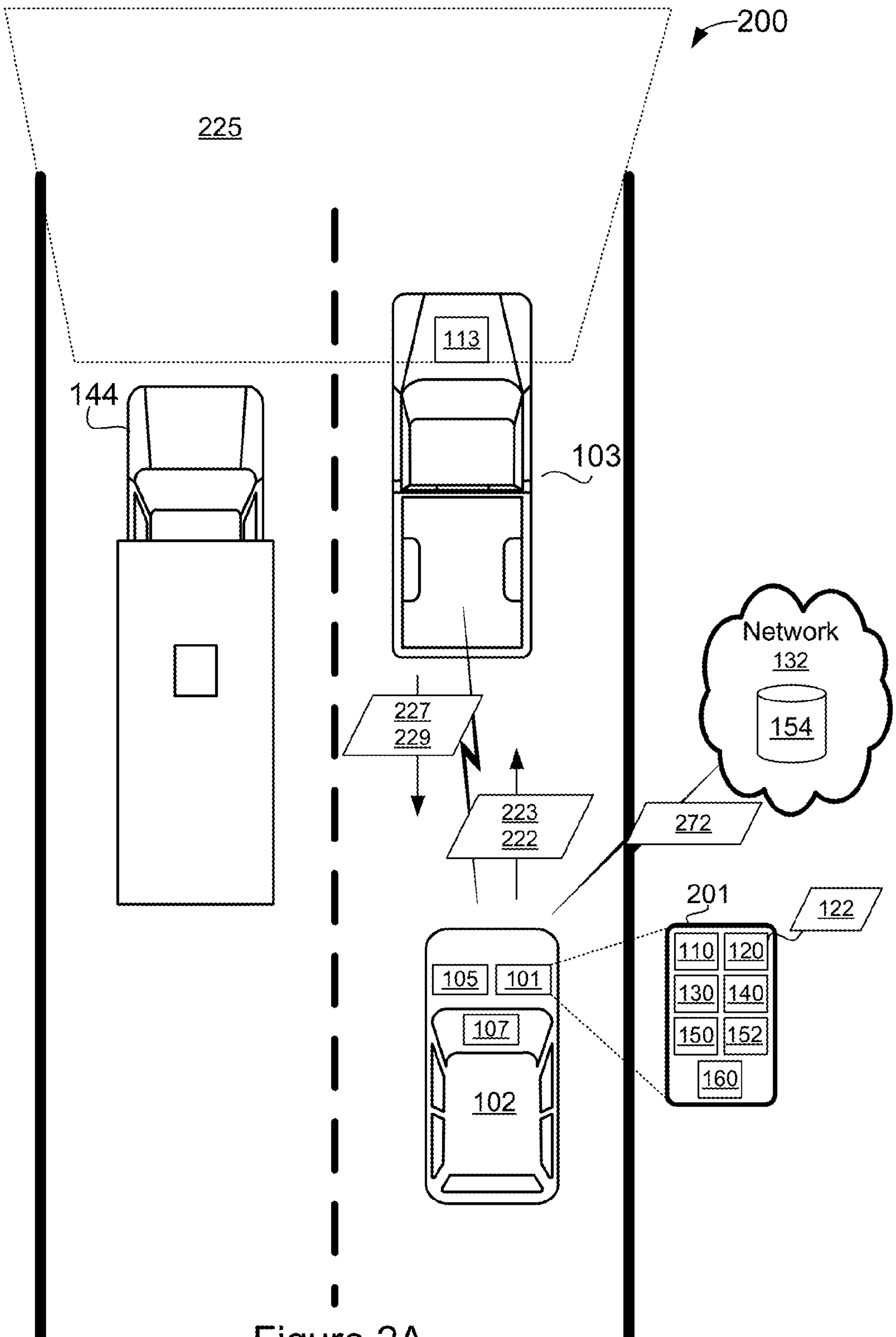
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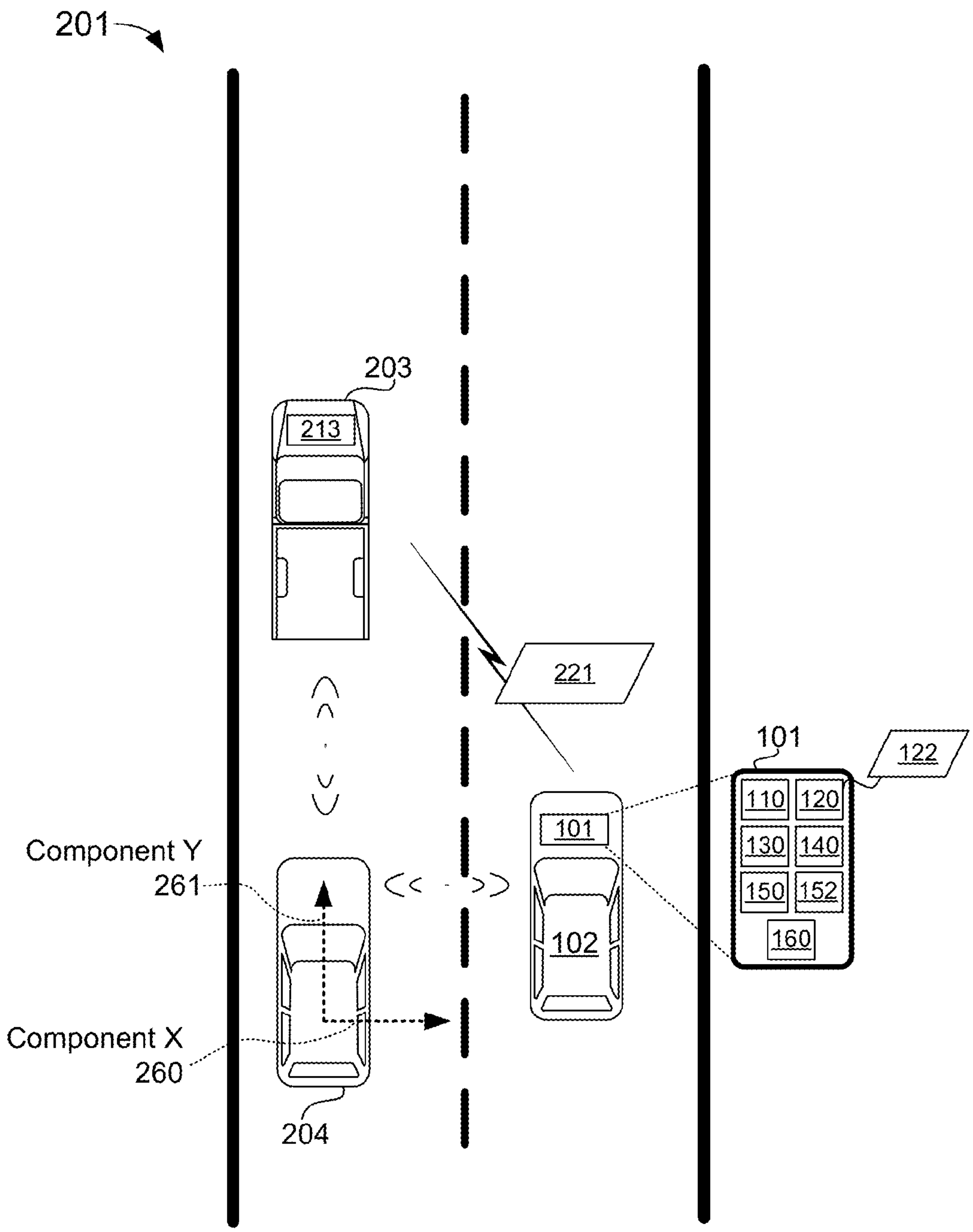
Figure 2A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Component X
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Figure 2B

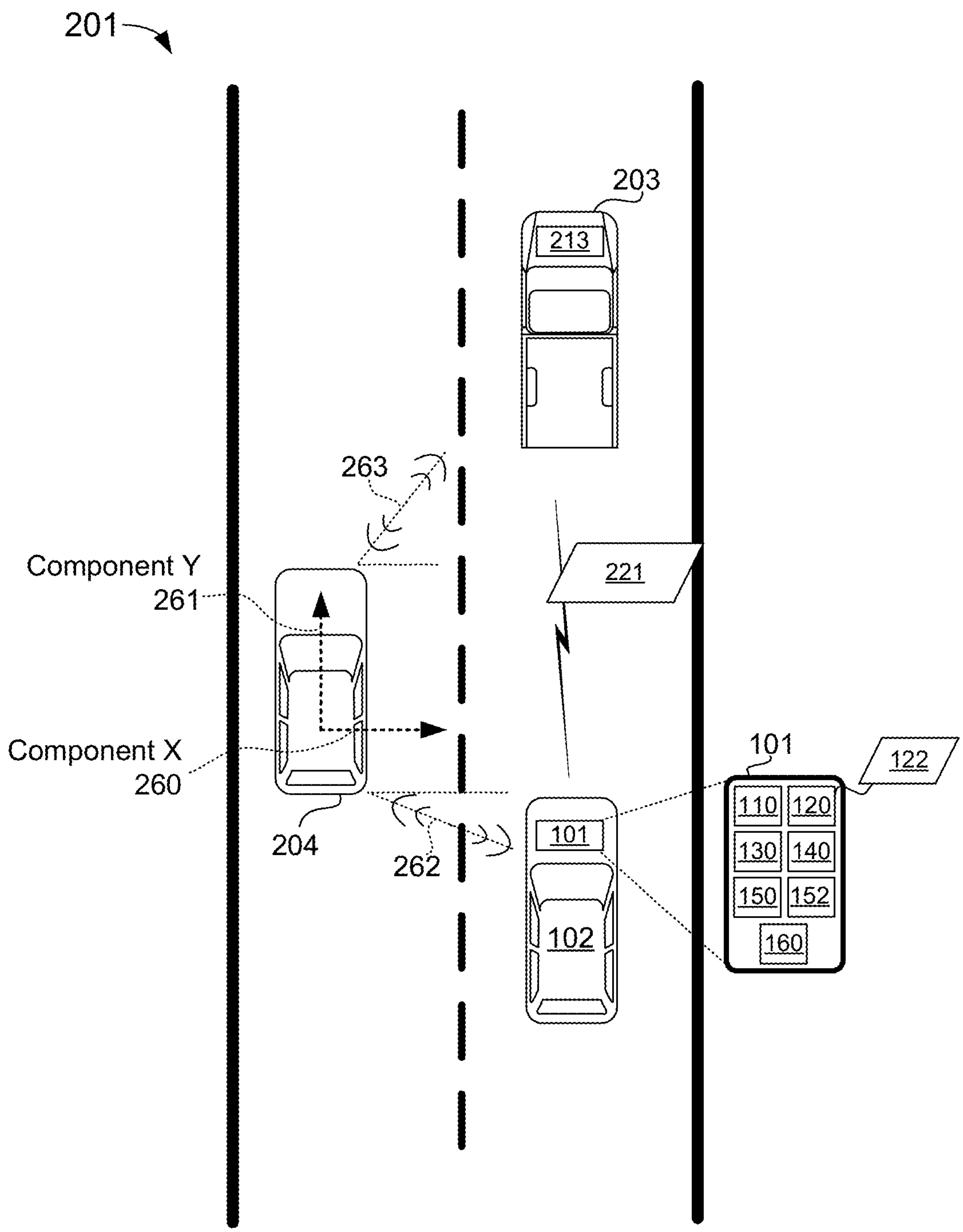
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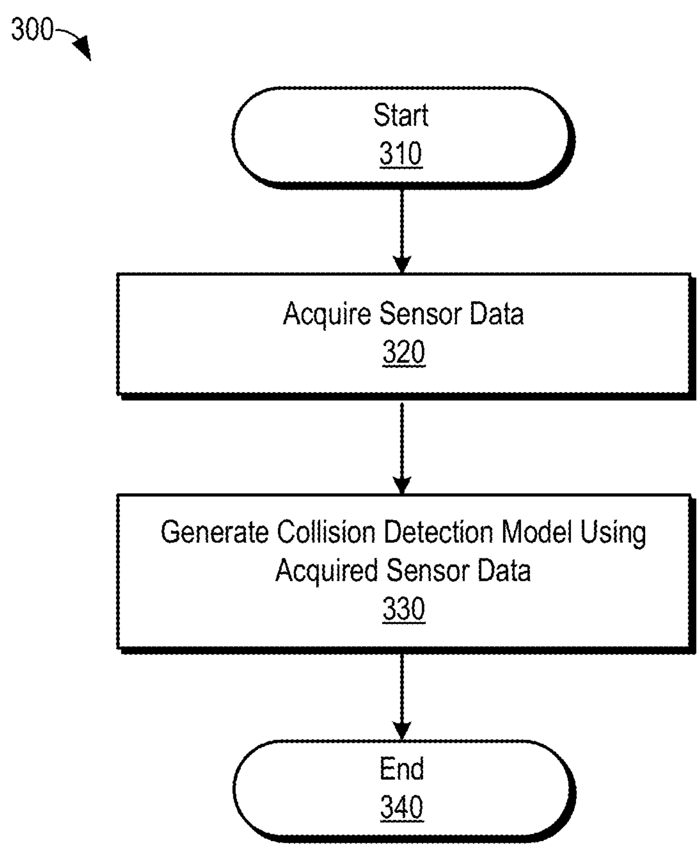
Figure 2C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Start
310
Acquire Sensor Data
320
Generate Collision Detection Model Using
Acquired Sensor Data
330
End
340

Figure 3

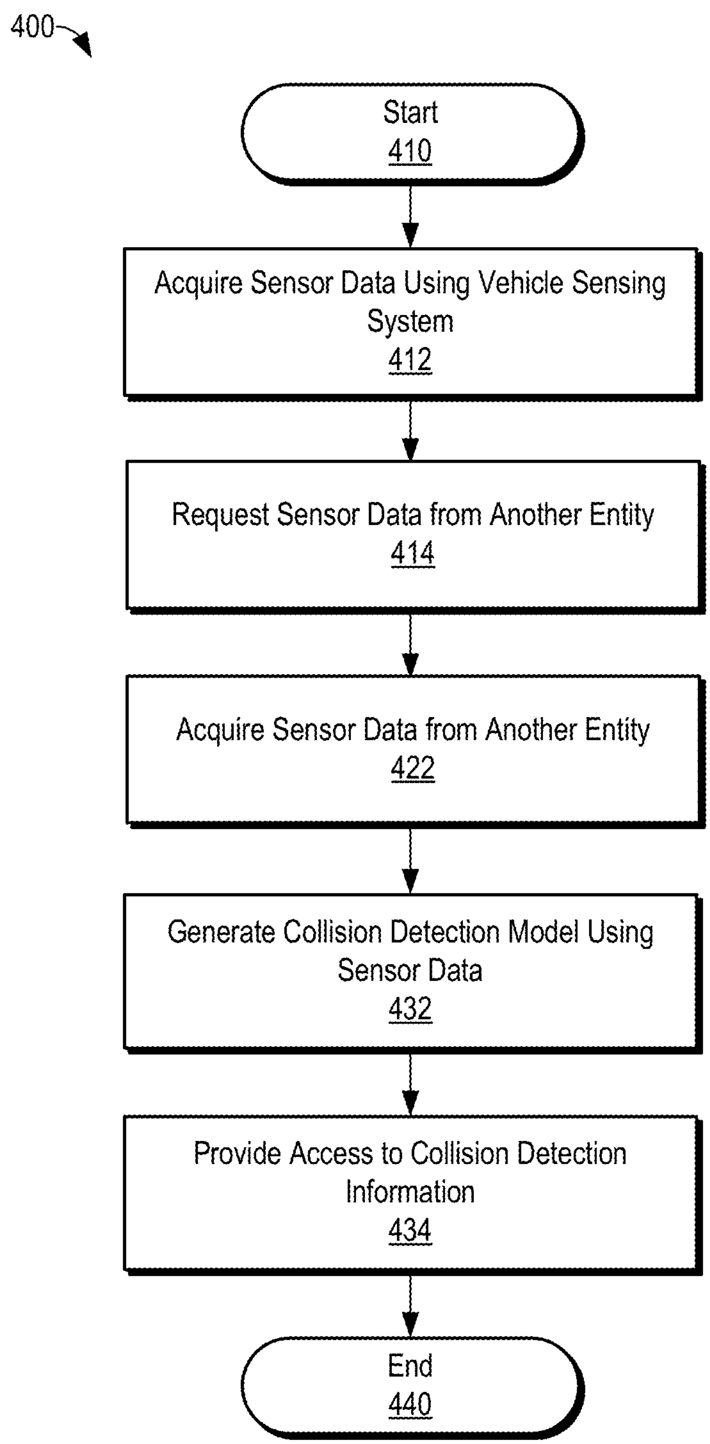
400
Start
410
Acquire Sensor Data Using Vehicle Sensing System
412
Request Sensor Data from Another Entity
414
Acquire Sensor Data from Another Entity
422
Generate Collision Detection Model Using Sensor Data
432
Provide Access to Collision Detection Information
434
End
440

Figure 4

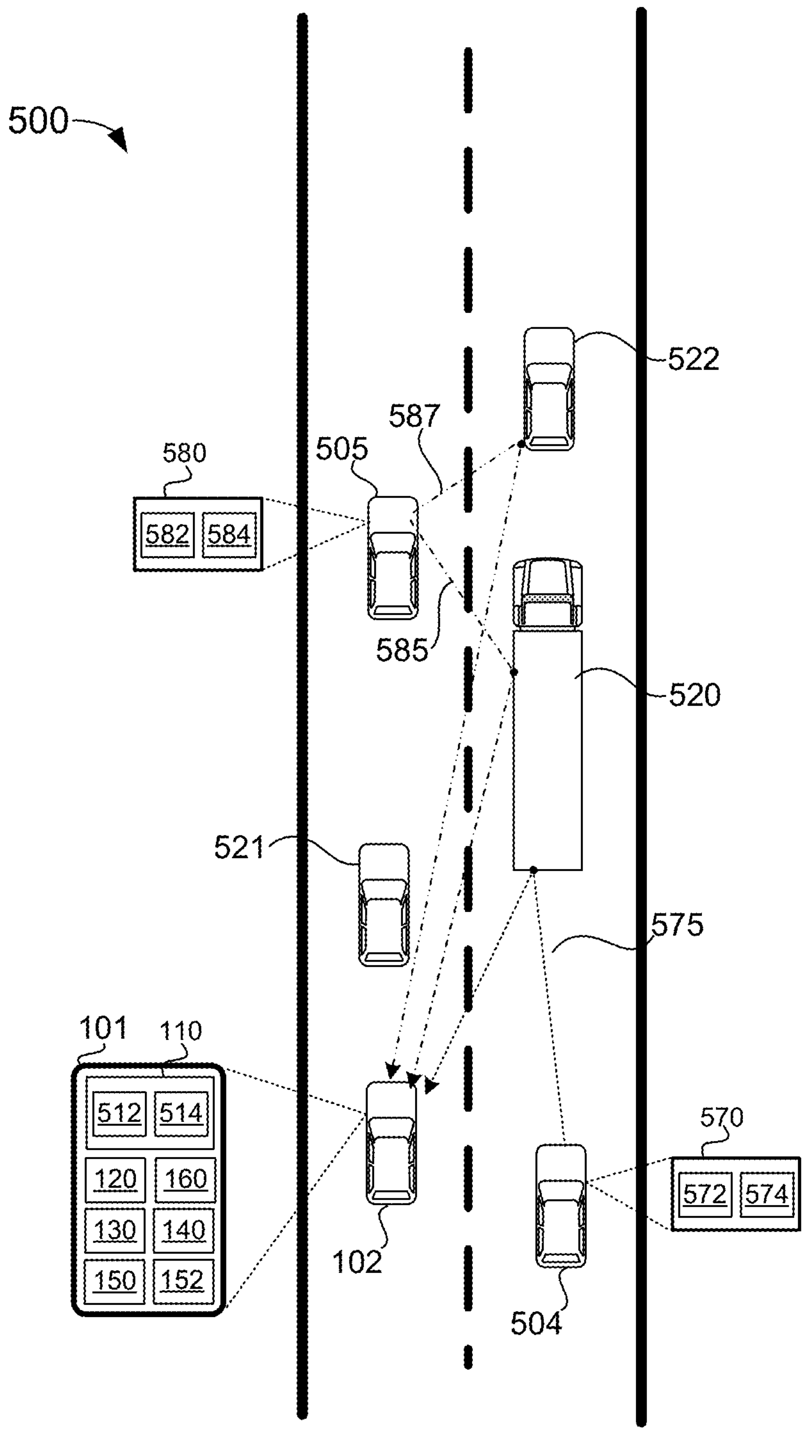
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Figure 5A

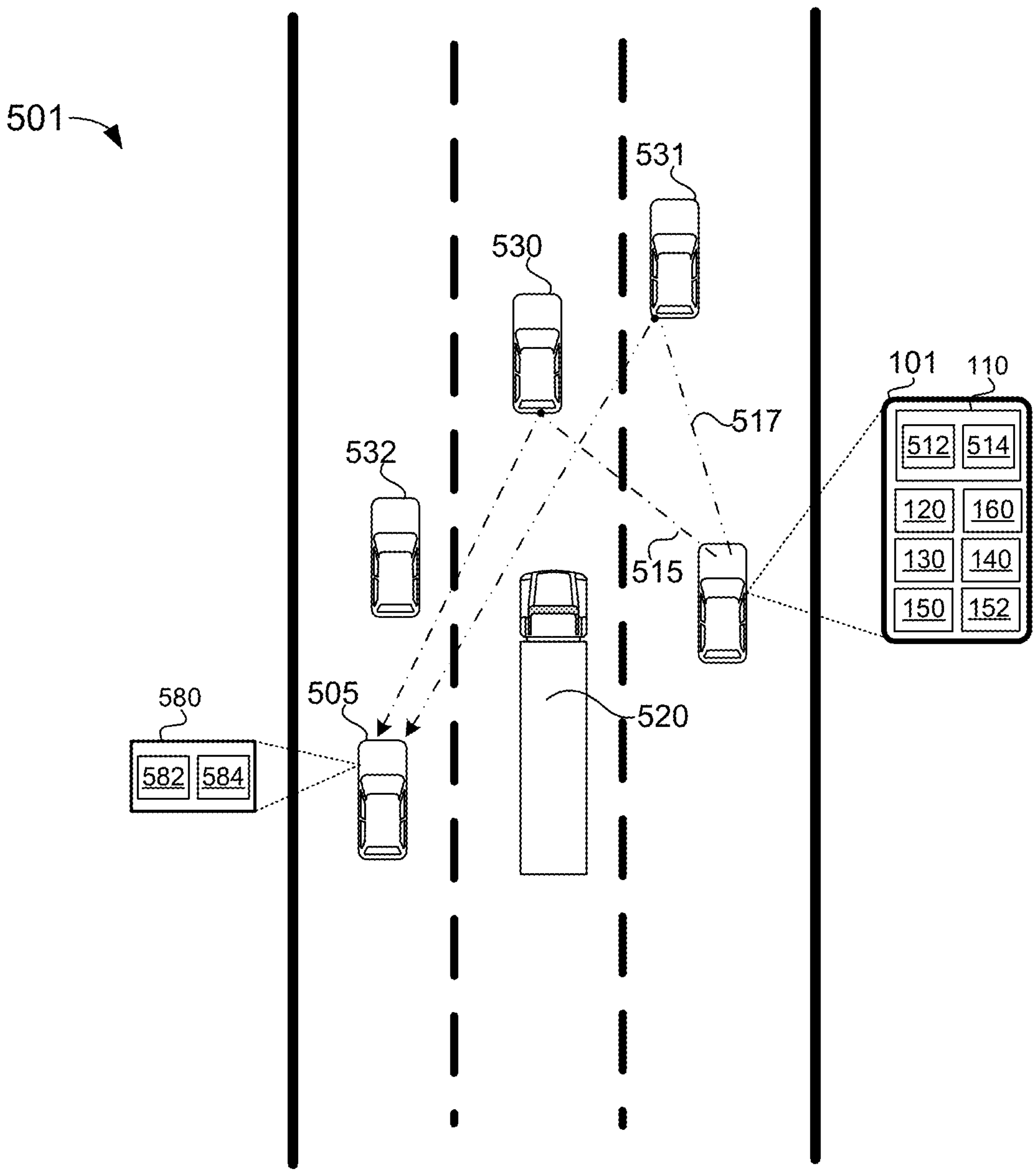

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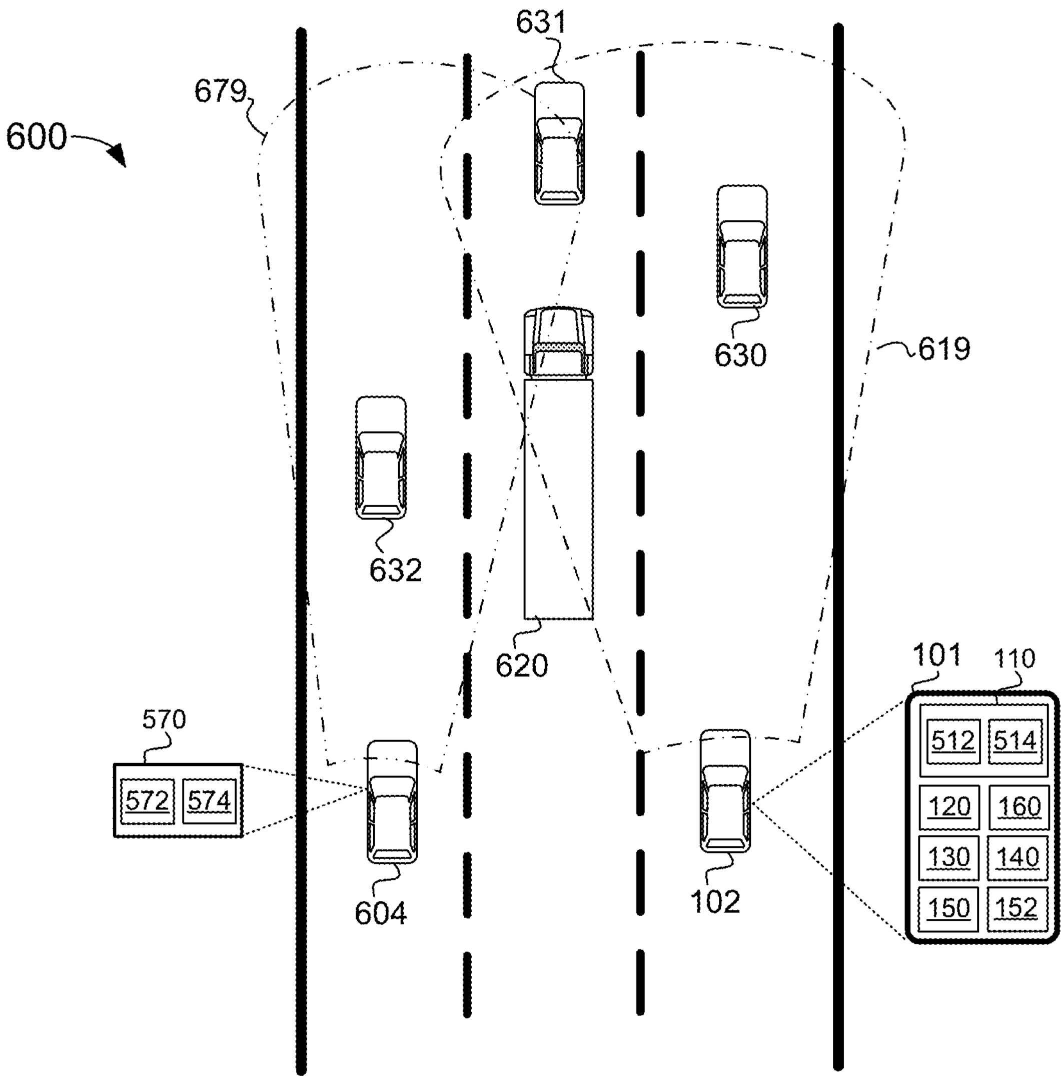
Figure 5B



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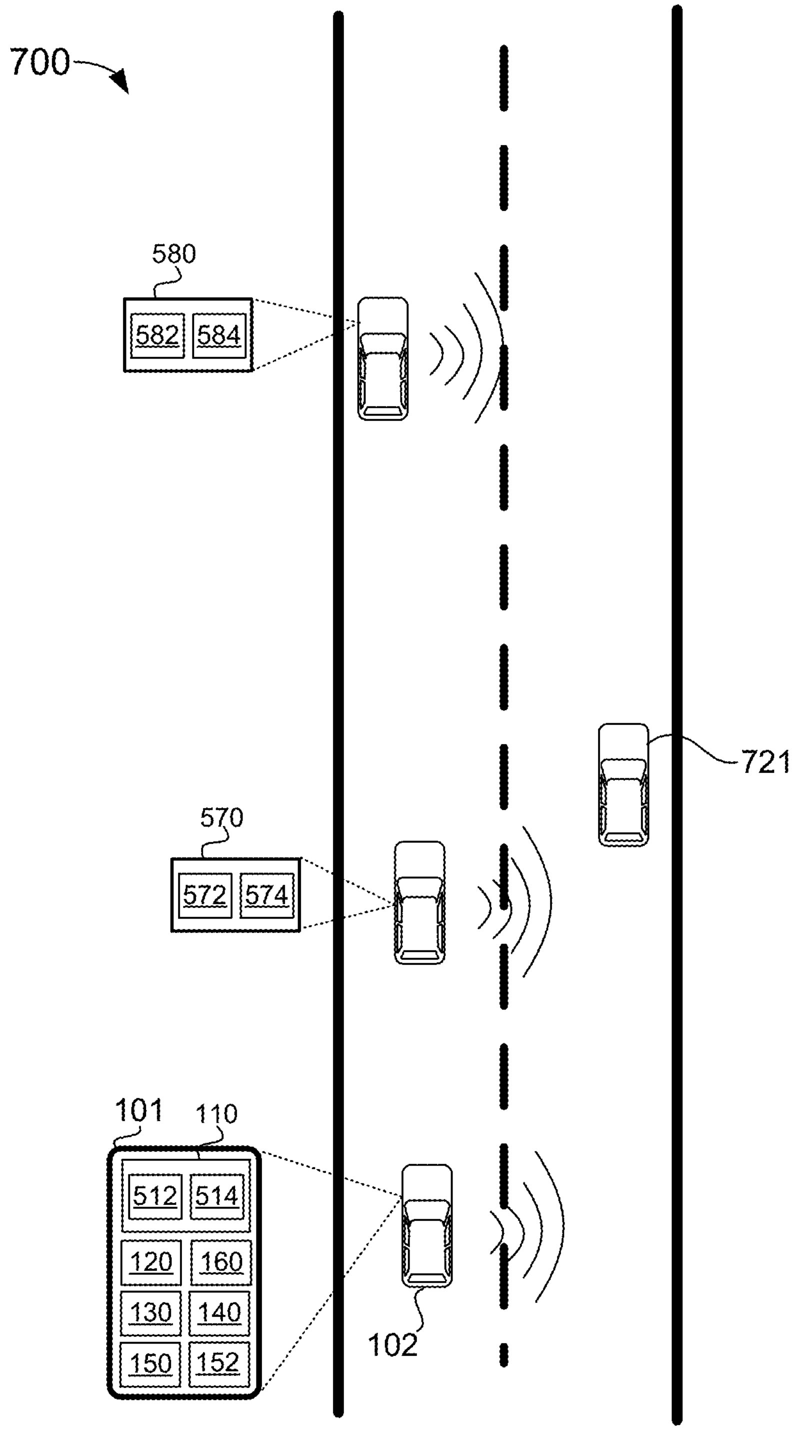
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Figure 7

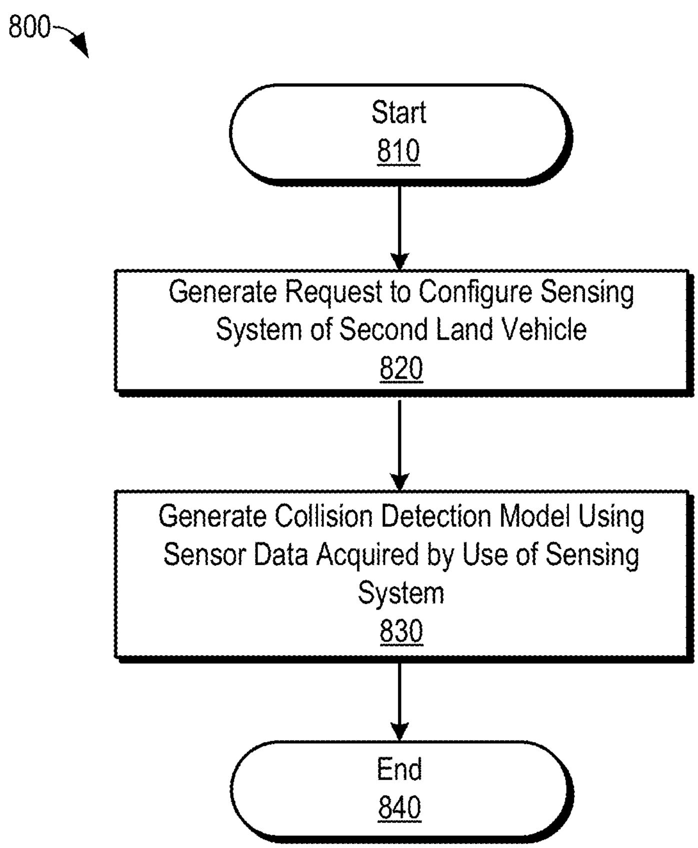

800
Start
810
Generate Request to Configure Sensing System of Second Land Vehicle
820
Generate Collision Detection Model Using Sensor Data Acquired by Use of Sensing System
830
End
840

Figure 8

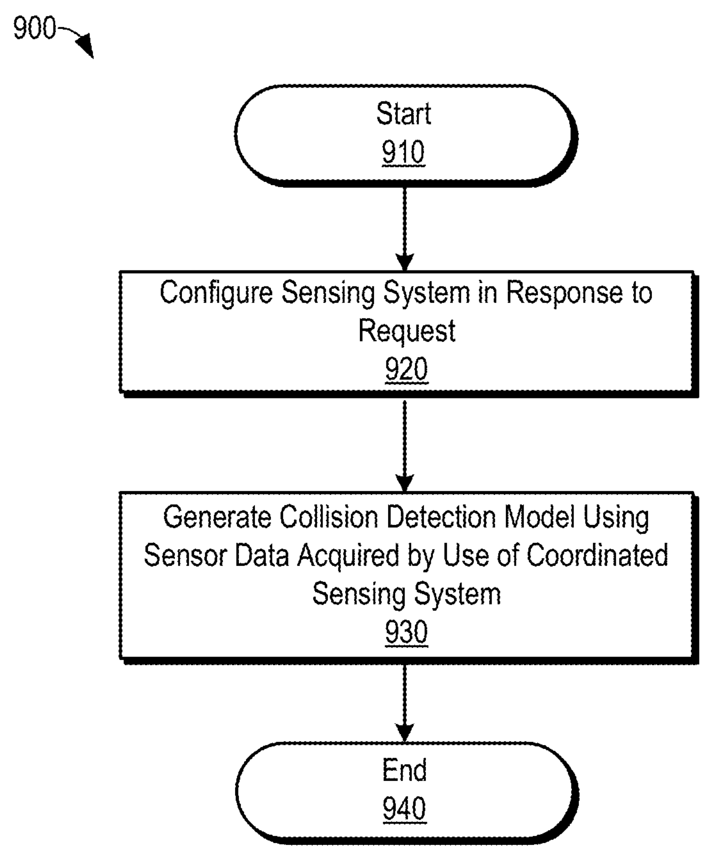
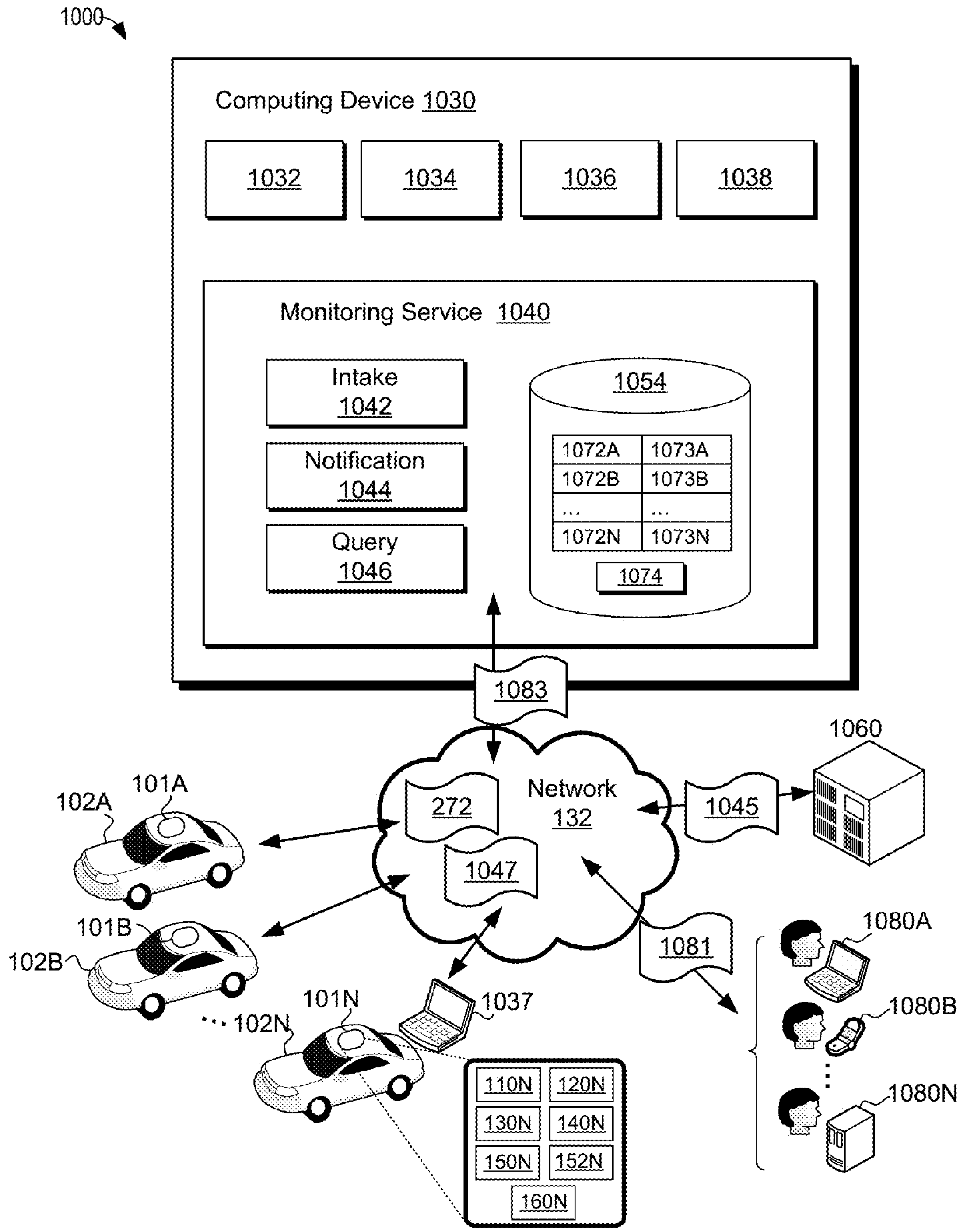

900
Start
910
Configure Sensing System in Response to Request
920
Generate Collision Detection Model Using Sensor Data Acquired by Use of Coordinated Sensing System
930
End
940

Figure 9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Notification 1044
Query 1046
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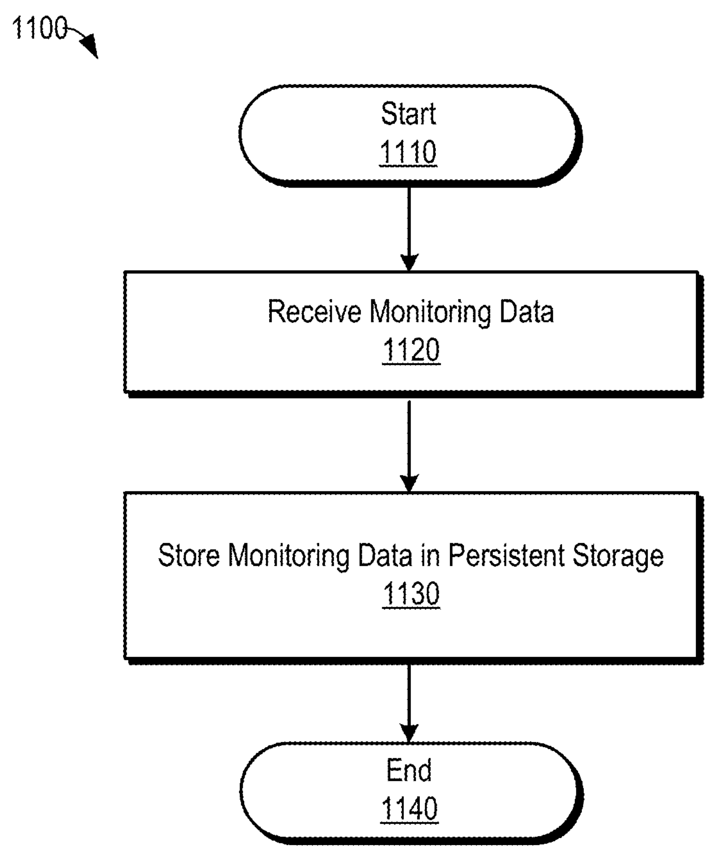
Figure 10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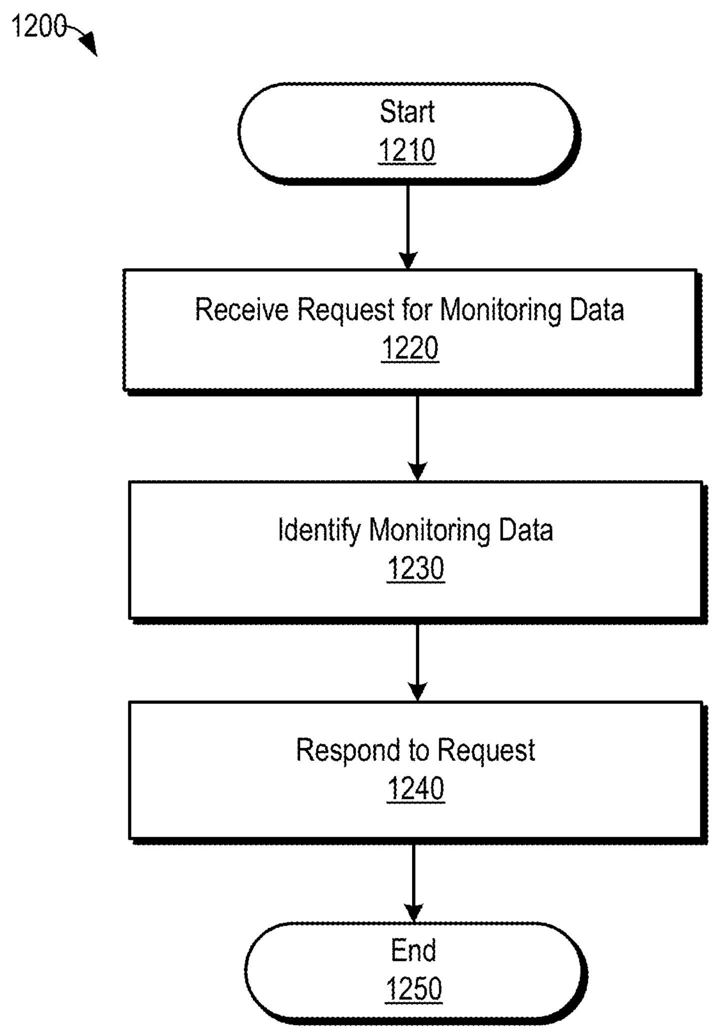
Receive Monitoring Data
1120
Store Monitoring Data in Persistent Storage
1130
End
1140

Figure 11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Start
1210
Receive Request for Monitoring Data
1220
Identify Monitoring Data
1230
Respond to Request
1240
End
1250

Figure 12

SYSTEMS AND METHODS FOR COORDINATING SENSOR OPERATION FOR COLLISION DETECTION

TECHNICAL FIELD

This disclosure relates to systems and methods for coordinating sensor operation for collision detection.

SUMMARY

A vehicle may comprise a collision detection system that is configured to detect potential collisions involving the vehicle and/or other objects in proximity to the vehicle. The objects may include, but are not limited to: pedestrians, animals, vehicles, road hazards, road features (e.g., barriers, bridge supports), and the like. The collision detection system may be configured to acquire sensor data using a sensing system of the vehicle and/or a sensing system of one or more other vehicles. The collision detection system may use the acquired sensor data to detect potential collisions. Detecting potential collisions may comprise accessing a collision detection model generated using the acquired sensor data. As used herein, a "collision detection model" refers to a kinematic object model of objects in a vicinity of the vehicle. The collision detection model may further comprise object position, orientation, size, and so on. In some embodiments, the collision detection model further comprises object weight estimates, maneuverability estimates, and so on. The collision detection model may comprise kinematics of objects relative to a particular frame of reference, such as relative position, velocity, acceleration, closing rate, orientation, and so on. The collision detection model may be translated between frames of reference for use in different vehicle collision detection systems. The collision detection model may be generated, in part, by the collision detection system of the vehicle. Alternatively, the collision detection model (and/or portions thereof) may be generated by other vehicles.

Collision detection systems may be configured to acquire sensor data from one or more sources, including, but not limited to: a sensing system of the collision detection system, sensing systems of other vehicles, and/or other external sources. In some embodiments, the collision detection system determines kinematic properties of objects using sensor data acquired by one or more sources. The collision detection system may combine sensor data to refine kinematic properties of an object, determine object position, orientation, size, and so on. The collision detection system may generate a collision detection model using the acquired sensor data. The collision detection system may coordinate with other vehicles to share collision detection data, such as sensor data, the collision detection model, and so on.

The collision detection system may be further configured to acquire auxiliary data from one or more other vehicles. Auxiliary data may comprise "self-knowledge," such as vehicle size, orientation, position, speed, and so on. The auxiliary data may comprise processed sensor data, such as speedometer readings, positioning system information, time information, and so on. In some embodiments, the collision detection system may use auxiliary data to combine sensor data and/or generate the collision detection model.

In some embodiments, the collision detection system may not utilize a sensing system, and may rely on sensor data acquired by other vehicles to detect potential collisions. Alternatively, or in addition, the collision detection system may fuse sensor data acquired using an internal sensing system with sensor data acquired from one or more external sources (e.g., other vehicles). Fusing the sensor data may comprise translating the sensor data into a suitable coordinate system and/or frame of reference, aligning the sensor data, weighting the sensor data, and so on. Fusing the sensor data may comprise weighting the sensor data, as described above.

The collision detection system may be further configured to coordinate sensor operation. In some embodiments, the collision detection system may coordinate sensor operation with other sensing systems to form a composite sensing system. The composite sensing system may comprise sensors of two or more vehicles. The composite sensing system may comprise one or more of: a multistatic sensor, a bistatic sensor, a monostatic sensor, and the like. The collision detection system may configure the sensing system to operate as a passive sensor (e.g., receiving detection signals originating from other vehicles), an active sensor (e.g., transmitting detection signals to be received at other vehicles), and/or a combination of active and passive operation.

The collision detection system may be configured to store monitoring data on a persistent storage device. Alternatively, or in addition, the collision detection system may transmit monitoring data to one or more network-accessible services. The monitoring data may comprise data pertaining to vehicle kinematics (and/or vehicle operation) before, during, and after a collision. The monitoring data may comprise sensor data, collision detection modeling data, and so on. The monitoring data may comprise time and/or location reference auxiliary data, vehicle identifying information, and so on. The monitoring data may be secured, such that the authenticity and/or source of the monitoring data can be verified.

A network accessible service may be configured to aggregate monitoring data from a plurality of vehicles. The network-accessible service may index and/or arrange monitoring data by time, location, vehicle identity, and the like. The network-accessible service may provide access to the monitoring data to one or more requesters via the network. Access to the monitoring data may be predicated on consideration, such as a payment, bid, reciprocal data access (to monitoring data of the requester), or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts one embodiment of a collision detection system;

FIG. **2**A depicts another embodiment of a cooperative collision detection system;

FIG. **2**B depicts another embodiment of a cooperative collision detection system;

FIG. **2**C depicts another embodiment of a cooperative collision detection system;

FIG. **3** is a flow diagram of one embodiment of a method for coordinating collision detection;

FIG. **4** is a flow diagram of another embodiment of a method for coordinating collision detection;

FIG. **5**A depicts one embodiment of a collision detection system configured to coordinate sensor operation;

FIG. **5**B depicts another embodiment of a collision detection system configured to coordinate sensor operation;

FIG. **6** depicts another embodiment of a collision detection system configured to coordinate sensor operation and/or share sensor data;

FIG. **7** depicts another embodiment of a collision detection system configured to coordinate sensor operation and/or share sensor data;

FIG. **8** is a flow diagram of one embodiment of a method for coordinating operation of a sensing system;

FIG. **9** is a flow diagram of another embodiment of a method for coordinating operation of a sensing system;

FIG. **10** is a block diagram of one embodiment of a monitoring service;

FIG. **11** is a flow diagram of one embodiment of a method for providing a monitoring service; and

FIG. **12** is a flow diagram of another embodiment of a method for providing a monitoring service.

DETAILED DESCRIPTION

Some of the infrastructure that can be used with embodiments disclosed herein is already available, such as: general-purpose computers, RF tags, RF antennas and associated readers, cameras and associated image processing components, microphones and associated audio processing components, computer programming tools and techniques, digital storage media, and communication networks. A computing device may include a processor, such as a microprocessor, microcontroller, logic circuitry, or the like. The processor may include a special purpose processing device, such as application-specific integrated circuits (ASIC), programmable array logic (PAL), programmable logic array (PLA), programmable logic device (PLD), field programmable gate array (FPGA), or other customizable and/or programmable device. The computing device may also include a machine-readable storage device, such as non-volatile memory, static RAM, dynamic RAM, ROM, CD-ROM, disk, tape, magnetic, optical, flash memory, or other machine-readable storage medium.

Various aspects of certain embodiments may be implemented using hardware, software, firmware, or a combination thereof. As used herein, a software module or component may include any type of computer instruction or computer executable code located within or on a machine-readable storage medium. A software module may, for instance, comprise one or more physical or logical blocks of computer instructions, which may be organized as a routine, a program, an object, a component, a data structure, etc. that performs one or more tasks or implements particular abstract data types.

In certain embodiments, a particular software module may comprise disparate instructions stored in different locations of a machine-readable storage medium, which together implement the described functionality of the module. Indeed, a module may comprise a single instruction or many instructions, and may be distributed over several different code segments, among different programs, and across several machine-readable storage media. Some embodiments may be practiced in a distributed computing environment where tasks are performed by a remote processing device linked through a communication network.

In the exemplary embodiments depicted in the drawings, the size, shape, orientation, placement, configuration, and/or other characteristics of tags, computing devices, advertisements, cameras, antennas, microphones, and other aspects of mobile devices are merely illustrative. Specifically, mobile devices, computing devices, tags, and associated electronic components may be manufactured at very small sizes and may not necessarily be as obtrusive as depicted in the drawings. Moreover, image, audio, and RF tags, which may be significantly smaller than illustrated, may be less intrusively placed and/or configured differently from those depicted in the drawings.

The embodiments of the disclosure will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout. The components of the disclosed embodiments, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Furthermore, the features, structures, and operations associated with one embodiment may be applicable to or combined with the features, structures, or operations described in conjunction with another embodiment. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of this disclosure.

Thus, the following detailed description of the embodiments of the systems and methods of the disclosure is not intended to limit the scope of the disclosure, as claimed, but is merely representative of possible embodiments. In addition, the steps of a method do not necessarily need to be executed in any specific order, or even sequentially, nor do the steps need to be executed only once.

A vehicle may comprise a collision detection system that is configured to detect potential collisions involving the vehicle and/or other objects in proximity to the vehicle. The objects may include, but are not limited to: pedestrians, animals, vehicles, road hazards, road features, and the like. The collision detection system may be configured to acquire sensor data using a sensing system of the vehicle and/or a sensing system of one or more other vehicles. The collision detection system may use the acquired sensor data to detect potential collisions. Detecting potential collisions may comprise accessing a collision detection model generated using the acquired sensor data. As used herein, a "collision detection model" refers to a kinematic object model of objects in a vicinity of the vehicle. The collision detection model may further comprise object position, orientation, size, and so on. In some embodiments, the collision detection model further comprises object weight estimates, maneuverability estimates, and so on. The collision detection model may comprise kinematics of objects relative to a particular frame of reference, such as relative position, velocity, acceleration, closing rate, orientation, and so on. The collision detection model may be translated between frames of reference for use in different vehicle collision detection systems. The collision detection model may be generated, in part, by the collision detection system of the vehicle. Alternatively, the collision detection model (and/or portions thereof) may be generated by other vehicles.

Collision detection systems may be configured to acquire sensor data from one or more sources, including, but not limited to: a sensing system of the collision detection system, sensing systems of other vehicles, and/or other external sources. In some embodiments, the collision detection system determines kinematic properties of objects using sensor data acquired by one or more sources. The collision detection system may combine sensor data to refine and/or determine kinematic information pertaining to an object, such as object acceleration, velocity, position, orientation, size, and so on. The collision detection system may generate a collision detection model using the acquired sensor data. The collision detection system may coordinate with other vehicles to share collision detection data, such as sensor data, the collision detection model, and so on.

The collision detection system may be further configured to acquire auxiliary data from one or more other vehicles. Auxiliary data may comprise "self-knowledge," such as vehicle size, orientation, position, speed, and so on. The auxiliary data may comprise processed sensor data, such as speedometer readings, positioning system information, time information, and so on. In some embodiments, the collision detection system may use auxiliary data to combine sensor data and/or generate the collision detection model.

In some embodiments, the collision detection system may not utilize a sensing system, and may rely on sensor data acquired by other vehicles to detect potential collisions. Alternatively, or in addition, the collision detection system may fuse sensor data acquired using an internal sensing system with sensor data acquired from one or more external sources (e.g., other vehicles). Fusing the sensor data may comprise translating the sensor data into a suitable coordinate system and/or frame of reference, aligning the sensor data, weighting the sensor data, and so on. Fusing the sensor data may comprise weighting the sensor data, as described above.

The collision detection system may be further configured to coordinate sensor operation. In some embodiments, the collision detection system may coordinate sensor operation with other sensing systems to form a composite sensing system. The composite sensing system may comprise sensors of two or more vehicles. The composite sensing system may comprise one or more of: a multistatic sensor, a bistatic sensor, a monostatic sensor, or the like. The collision detection system may configure the sensing system to operate as a passive sensor (e.g., receiving detection signals originating from other vehicles), an active sensor (e.g., transmitting detection signals to be received at other vehicles), and/or a combination of active and passive operation.

The collision detection system may be configured to store monitoring data on a persistent storage device. Alternatively, or in addition, the collision detection system may transmit monitoring data to one or more network-accessible services. The monitoring data may comprise data pertaining to vehicle kinematics (and/or vehicle operation) before, during, and after a collision. The monitoring data may comprise sensor data, collision detection modeling data, and so on. The monitoring data may comprise time and/or location reference auxiliary data, vehicle identifying information, and so on. The monitoring data may be secured, such that the authenticity and/or source of the monitoring data can be verified.

A network accessible service may be configured to aggregate monitoring data from a plurality of vehicles. The network-accessible service may index and/or arrange monitoring data by time, location, vehicle identity, or the like. The network-accessible service may provide access to the monitoring data to one or more requesters via the network. Access to the monitoring data may be predicated on consideration, such as a payment, bid, reciprocal access (to monitoring data of the requester), or the like.

FIG. **1** is a block diagram **100** depicting one embodiment of a collision detection system **101**. The collision detection system **101** may be deployed within a ground vehicle **102**, such as a car, truck, bus, or the like. The collision detection system **101** may comprise a sensing system **110**, a processing module **120**, a communication module **130**, a vehicle interface module **140**, a storage module **150**, and a coordination module **160**. The sensing system **110** may be configured to acquire information pertaining to objects within a detection range **112** of the vehicle **102**. The processing module **120** may use information obtained by the sensing system **110** (and/or other sources of sensor data) to detect potential collisions. Detecting a potential collision may comprise identifying objects involved in the potential collision, determining a time frame of the collision (e.g., time to the collision), and so on. The communication module **130** may be used to communicate with other vehicles (e.g., vehicles **103** and/or **104**), emergency service entities, a network **132**, network-accessible services **154**, and the like. The storage module **150** may be used to store a configuration of the collision detection system **101**, operating conditions of the vehicle **102** and/or pericollisional information, and so on. The coordination module **160** may be configured to coordinate operation of the collision detection system **101** and/or sensing system **110** with other vehicles **103**,**104**.

The sensing system **110** may be configured to acquire information pertaining to objects that could pose a collision risk to the vehicle **102** (and/or other vehicles **103**, **104**). The sensing system **110** may be further configured to acquire information pertaining to the operation of the vehicle **102**, such as orientation, position, velocity, acceleration, and so on. In some embodiments, the sensing system **110** is configured to acquire kinematic information. As used herein, kinematics refers to object motion characteristics; kinematic information may include, but is not limited to: velocity, acceleration, orientation, and so on. Kinematic information may be expressed using any suitable coordinate system and/or frame of reference. Accordingly, kinematic information may be represented as component values, vector quantities, or the like, in a Cartesian coordinate system, a polar coordinate system, or the like. Furthermore, kinematic information may be relative to a particular frame of reference; for example; kinematic information may comprise object orientation, position, velocity, acceleration (e.g., closing rate), and so on relative to an orientation, position, velocity, and/or acceleration of a particular vehicle **102**, **103**, and/or **104**.

The sensing system **110** may comprise one or more active and/or passive sensors, which may include, but are not limited to, one or more electro-magnetic sensing systems (e.g., radar sensing systems, capacitive sensing systems, etc.), electro-optical sensing systems (e.g., laser sensing system, Light Detection and Ranging (LIDAR) systems, etc.), acoustic sensing systems, ultrasonic sensing systems, magnetic sensing systems, imaging systems (e.g., cameras, image processing systems, stereoscopic cameras, etc.), and the like. The collision detection system **101** may further comprise sensors for determining the kinematics of the vehicle **102** (e.g., "self-knowledge"). Accordingly, the sensing system **110** may comprise one or more speedometers, accelerometers, gyroscopes, information receiving systems (e.g., Global Positioning System (GPS) receiver), wireless network interface, etc.), and the like. Alternatively, or in addition, the collision detection system **101** may comprise (or be communicatively coupled to) a control system **105** of the vehicle **102**. As used herein, a vehicle "control system" refers to a system for providing control inputs to a vehicle, such as steering, braking, acceleration, and so on. The collision detection system **101** may incorporate portions of the vehicle control system **105**, such as a sensor for determining velocity, acceleration, braking performance (e.g., an anti-lock braking system), and the like. The collision detection system **101** may be further configured to monitor control system inputs **105** to predict changes to vehicle kinematics (e.g., predict changes to acceleration based upon operator control of accelerator and/or braking inputs). Although particular examples of sensing systems are provided herein, the disclosure is not limited in this regard and could incorporate any sensing system **110** comprising any type and/or number of sensors.

The sensing system **110** may be configured to provide sensor data to other vehicles **103**, **104** and/or receive sensor data from other vehicles **103**, **104**. In some embodiments, the sensing system **110** may coordinate sensor operation with other vehicles; for example, the sensing system **110** may act as a transmitter for one or more other sensing systems (not shown), and/or vice versa.

The sensing system **110** may be capable of acquiring information pertaining to objects within a detection range **112** of the vehicle **102**. As used herein, a "detection range" of the sensing system **110** refers to a range at which the sensing system **110** is capable of acquiring (and/or configured to acquire) object information. As used herein, the detection range **112** of the sensing system **110** may refer to a detection envelope of the sensing system **110**. In some embodiments, the detection range **112** may be more limited than the maximum detection range of the sensing system **110** (the maximum range at which the sensing system **110** can reliably acquire object information). The detection range **112** may be set by user configuration and/or may be determined automatically based upon operating conditions of the vehicle **102**, such as vehicle velocity and/or direction, velocity of other objects, weather conditions, and so on. For example, the detection range **112** may be reduced in response to the vehicle **102** traveling at a low velocity and may expand in response to the vehicle **102** traveling at higher velocities. Similarly, the detection range **112** may be based upon the kinematics of other objects in the vicinity of the vehicle **102**. For example, the detection range **112** may expand in response to detecting another vehicle **103** travelling at a high velocity relative to the vehicle **102**, even though the vehicle **102** is traveling at a low velocity.

In some embodiments, the sensing system **110** may comprise directional sensors (e.g., a beam forming radar, phased array, etc.). The collision detection system **101** may shape and/or direct the detection range **112** of the sensing system **110** in response to operating conditions. For example, when the vehicle **102** is travelling forward at a high velocity, the detection range **112** may be directed toward the front of the vehicle **102**; when the vehicle **102** is turning, the detection range **112** may be steered in the direction of the turn; and so on.

The collision detection system **101** may cooperate with other vehicles using the communication module **130**. The communication module **130** may include, but is not limited to, one or more: wireless network interfaces, cellular data interfaces, satellite communication interfaces, electro-optical network interfaces (e.g., infrared communication interfaces), and the like. The communication module **130** may be configured to communicate in point-to-point "ad-hoc" networks and/or infrastructure networks **132**, such as an Internet Protocol network (e.g., the Internet, a local area network, a wide area network, or the like).

In some embodiments, the collision detection system **101** may be configured to coordinate with other vehicles (e.g., other sensing systems and/or other collision detection systems). The coordination may comprise acquiring sensor data from other entities (e.g., other vehicles **103**, **104**) and/or providing sensor data acquired by the sensing system **110** to other entities. The coordination may further comprise sharing collision detection data, such as portions of a collision detection model **122**, collision detection data and/or alerts, and so on.

The coordination may allow the collision detection system **101** to acquire sensor data pertaining to areas outside of the detection range **112** of the sensing system **110** (e.g., expand the detection range **112** of the collision detection system). Similarly, the collision detection system **101** may acquire sensor data pertaining to areas that are inaccessible to the sensing system **110** (e.g., areas that are obscured by other objects). For example, as depicted in FIG. **1**, the position of vehicle **103** may prevent the sensing system **110** from reliably acquiring sensor data pertaining to area **125**. The collision detection system **101** may acquire sensor data pertaining to area **125** from another source, such as a sensing system **113** of vehicle **103** and/or the sensing system **114** of vehicle **104**. As described below, sensor data coordination may further comprise determining and/or refining kinematic information (e.g., vector components) and determining and/or refining object position (e.g., by triangulating sensor data), size, angular extent, angle-dependent range, orientation, and so on.

The collision detection system **101** may be further configured to provide sensor data acquired by the sensing system **110** to other entities, such as the vehicles **103**, **104**. The collision detection system **101** may make sensor data available via the communication module **130** (e.g., may broadcast sensor data). Alternatively, or in addition, the collision detection system **101** may provide sensor data (and/or other information related to the collision detection system **101**) in response to requests from other entities (e.g., via a point-to-point communication mechanism).

In some embodiments, the collision detection system may be configured to coordinate operation with other entities using, inter alia, the coordination module **160**. For example, the sensing system **110** may be capable of obtaining reliable, accurate information pertaining to objects in a particular area **127**, but may not be capable of reliably obtaining information pertaining to objects in other areas (e.g., area **125**). The collision detection system **101** may coordinate with other sensing systems **113** and/or **114** to provide those sensing systems **113**, **114** with sensor data pertaining to objects in area **127**. In exchange, the other sensing systems **113**, **114** may provide the collision detection system **101** with sensor data pertaining to objects in other areas, such as area **125**. This coordination may comprise the collision detection system **101** configuring the detection range **112** of the sensing system **110** (e.g., by beam forming, steering, or the like) to acquire information pertaining to area **127** to the exclusion of other areas, which will be provided by the sensing systems **113**, **114**.

In some embodiments, the collision detection system **101** may coordinate sensor operation and/or configuration with other sensing systems **113**, **114**. As described in greater detail below, the coordination module **160** may configure the sensing system **110** to: act as a transmitter for other sensing systems **113**, **114** (e.g., in a bistatic and/or multistatic sensor configuration); act as a receiver to detect a sensor signal transmitted by one or more other sensing systems **113**, **114**; act as a combination transmitter/receiver in combination with other sensing systems **113**, **114**; and so on.

The collision detection system **101** may further comprise a processing module **120**, which may use the information acquired by the sensing system **110** (and/or obtained from other sources) to detect potential collisions. The processing module **120** may comprise one or more processors, including, but not limited to: a general-purpose microprocessor, a microcontroller, logic circuitry, an ASIC, an FPGA, PAL, PLD, PLA, and the like. The processing module **120** may further comprise volatile memory, persistent, machine-readable storage media **152** and the like. The persistent machine-readable storage media **152** may comprise machine-readable storage medium configured to cause the processing module **120** to operate and/or configure the sensing system **110**, coordinate with other collision detection systems (e.g., via the communication and/or coordination modules **130**, **160**), detect potential collisions, and so on, as described herein.

The processing module **120** may be configured to detect potential collisions. The processing module **120** may detect potential collisions using information obtained from any number of sources, including, but not limited to: sensor data acquired from the sensing system **110**; sensor data acquired from and/or in cooperation with other sensing systems (e.g., sensing systems **113**, **114**); collision detection data acquired from other collision detection systems; information received via the communication module **130** (e.g., from a public safety entity, weather service, or the like); and so on.

The processing module **120** may detect potential collisions using any suitable detection technique. In some embodiments, the processing module **120** detects potential collisions using a collision detection model **122**. As used herein, a "collision detection model" refers to a model of object kinematics. The collision detection model may include, but is not limited to: object size, position, orientation, velocity, acceleration (e.g., closing rate), angular extent, angle-dependent range, and so on. The kinematics of the collision detection model may be relative to the vehicle **102** (e.g., relative velocity, acceleration, and so on). Alternatively, the collision detection model may incorporate the kinematics of the vehicle **102** and/or may be defined in another frame of reference (e.g., GPS position, frame of reference of another vehicle **103**,**104**, or the like). The processing module **120** may use the collision detection model **112** to extrapolate and/or predict object kinematics, which may indicate potential object collisions (e.g., object intersections within the collision detection model), the time to a potential collision, impact velocity of the potential collision, forces involved in a potential collision, a potential result of a collision, and so on.

The collision detection model **122** may further comprise information pertaining to current operating conditions, such as road conditions, visibility, and so on. For example, the collision detection model **122** may comprise information pertaining to the condition of the operating surface (e.g., roadway), such as whether the roadway is muddy, wet, icy, snowy, or the like. The processing module **120** may use current operating condition information to estimate the probability (and/or ability) of objects to maneuver to, inter alia, avoid potential collisions (e.g., turn, decelerate, and so on).

In some embodiments, the collision detection model **122** may further comprise predictive information. For example, the collision detection model **122** may comprise estimates of object size, weight, and so on. The predictive information may be used to determine object momentum and other characteristics, which may be used to determine a potential result of a collision (e.g., object kinematics after a potential collision has occurred). For example, in the FIG. **1** example, the collision detection system **101** may determine a potential result of a collision between vehicles **103** and **104**, which may comprise estimating kinematics of the vehicles **103**, **104** after the potential collision has occurred.

The collision detection model **122** may further comprise collision avoidance information, which may comprise instructions on how to avoid potential collisions detected by the processing module **120**. The collision avoidance information may pertain to the vehicle **102** and/or other vehicles **103**, **104**. For example, the collision avoidance information may comprise information for avoiding a potential collision between vehicles **103** and **104**. The collision avoidance information may further comprise information to allow the vehicle **102** to avoid becoming involved in the collision (e.g., avoid a potential result of the collision).

The collision detection system **101** may be configured to take one or more actions in response to detecting a potential collision. Such actions may include, but are not limited to: alerting the operator of the vehicle **102** to the potential collision, determining a collision avoidance action, determining a potential result of the collision (e.g., estimate object kinematics after the collision), determining actions to avoid the potential result, automatically taking one or more collision avoidance actions, transmitting the collision detection model **122** to other vehicles (and/or a portion thereof), coordinating a response to the potential collision with other vehicles, contacting an emergency services entity, and so on.

The coordination module **160** may make portions of the collision detection model **122** available to other vehicles **103**, **104** (via the communication module **130**). Alternatively, or in addition, the coordination module **160** may be configured to receive collision detection data from other vehicles **103**, **104**. The collision detection data may comprise sensor data, a collision detection model (and/or portions thereof), vehicle kinematics, collision detections, avoidance information, and so on.

The collision detection system **101** may comprise and/or be communicatively coupled to human-machine interface components **107** of the vehicle **102**. The human-machine interface components **107** may include, but are not limited to: visual display components (e.g., display screens, heads-up displays, or the like), audio components (e.g., a vehicle audio system, speakers, or the like), haptic components (e.g., power steering controls, force feedback systems, or the like), and so on.

The collision detection system **101** may use the human-machine interface components **107** to alert an operator of the vehicle **102** to a potential collision. The alert may comprise one or more of: an audible alert (e.g., alarm), a visual alert, a haptic alert, or the like. In some embodiments, the alert may comprise collision avoidance instructions to assist the operator in avoiding the potential collision (and/or a result of a potential collision involving other vehicles). The avoidance instructions may be provided as one or more audible instructions, visual cues (e.g., displayed on a heads-up display), haptic stimuli, or the like. For example, collision avoidance instructions may be conveyed audibly through a speaker system of the vehicle (e.g., instructions to "veer left"), visually through icons on a display interface (e.g., a turn icon, brake icon, release brake icon, etc.), and/or by haptic feedback (e.g., vibrating a surface, actuating a control input, and so on). Although particular examples of alerts are described herein, the disclosure is not limited in this regard and could be adapted to incorporate any suitable human-machine interface components **107**.

As discussed above, the collision detection system **101** may be configured to take one or more automatic collision avoidance actions in response to detecting a potential collision. The collision avoidance actions may include, but are not limited to: accelerating, decelerating, turning, actuating vehicle systems (e.g., lighting systems, horn, etc.), and so on. Accordingly, the collision detection system **101** may be communicatively coupled to the control system **105** of the vehicle **102**, and may be capable of providing control inputs thereto. The automatic collision avoidance actions may be configured to prevent the potential collision, avoid a result of the potential collision (e.g., a collision involving other vehicles), and so on. The automatic collision avoidance actions may be determined in cooperation with other vehicles. For example, the collision detection system **101** may cooperate with the vehicle **103** to determine collision avoidance actions (or instructions) that allow both vehicles **102**, **103** to avoid the potential collision, while also avoiding each other.

The collision detection system **101** may be configured to implement the automatic collision avoidance actions without the consent and/or intervention of the vehicle operator. Alternatively, or in addition, the collision detection system **101** may request consent from the operator before taking the automatic collision avoidance actions. The human-machine interface module **107** may comprise one or more inputs configured to allow the vehicle operator to indicate consent, such as a button on a control surface (e.g., steering wheel), an audio input, a visual input, or the like. The consent may be requested at the time a potential collision is detected and/or may be requested a priori, before a potential collision is detected. The consent may expire after a pre-determined time and/or in response to certain, pre-determined conditions (e.g., after the potential collision has been avoided, after the vehicle **102** is shut down, etc.). Accordingly, the collision detection system **101** may be configured to periodically re-request the consent of the vehicle operator. For example, the collision detection system **101** may request consent to implement automatic collision avoidance actions each time the vehicle **102** is started.

The collision detection system **101** may be configured such that the automatic collision avoidance actions cannot be overridden by the vehicle operator. Accordingly, the collision detection system **101** may be configured to "lock out" the vehicle operator from portions of the control system **105**. Access to the vehicle control system **105** may be restored after the automatic collision avoidance actions are complete and/or the collision detection system **101** determines that the potential collision has been avoided. The collision detection system **101** may be configured to "lock out" the vehicle operator from all vehicle control operations. Alternatively, the vehicle operator may be allowed limited access to the control system **105**. For example, the control system **105** may accept operator inputs that do not interfere and/or conflict with the automatic collision avoidance actions (e.g., the vehicle operator may be allowed to provide limited steering input, but not acceleration/deceleration).

Alternatively, the collision detection system **101** may be configured to allow the vehicle operator to override one or more of the automatic collision avoidance actions. In response to an override, the collision detection system **101** may stop implementing automatic collision avoidance actions and may return control to the vehicle operator. An override may comprise the vehicle operator providing an input to the control system **105** (or other human-machine interface component **107**). In another example, the collision detection system **101** may implement the automatic collision avoidance actions by actuating controls of the vehicle **102** (e.g., turning the steering wheel), and an override may comprise the vehicle operator resisting or counteracting the automatic control actuations.

In some embodiments, the collision detection system **101** may be capable of preemptively deploying and/or configured to preemptively deploy safety systems of the vehicle **102**. For example, the collision detection system **101** may be configured to deploy one or more airbags before the impact of the collision occurs. The collision detection system **101** may be further configured to adapt the deployment of the safety systems to the imminent collision (e.g., adapt safety system deployment in accordance with the location on the vehicle **102** where a collision impact is to occur).

The collision detection system **101** may continue to monitor object kinematics after detecting a potential collision and taking any of the actions described above. The collision detection system **101** may continue to revise and/or update the actions described above in response to changing kinematics (e.g., the result of one or more collisions, the actions of other vehicles **103**,**104**, and the like).

The collision detection system **101** may further comprise a storage module **150** that is configured to store information pertaining to the capabilities, configuration, and/or operating state of the collision detection system **101** (and/or vehicle **102**). The storage module **150** may comprise persistent, machine-readable storage media **152**, such as hard disks, solid-state storage, optical storage media, or the like. Alternatively, or in addition, the storage module **150** may be configured to store data in a network-accessible service **154**, such as a cloud storage service or the like (via the communication module **130**).

The storage module **150** may be configured to store any information pertaining to the vehicle **102**, which may include, but is not limited to: kinematics of the vehicle **102**, operator control inputs (e.g., steering, braking, etc.), the collision detection model **122** (e.g., kinematics of other vehicles, collision detections, etc.), actions taken in response to detecting potential collisions, operator override of automatic collision avoidance actions, communication with other vehicles, and so on. Accordingly, the storage module **150** may act as a "black box" detailing the operating conditions of the vehicle **102** and/or other peri-collisional circumstances.

The storage module **150** may be configured to prevent unauthorized access to and/or modification of stored information. Accordingly, the storage module **150** may be configured to encrypt information for storage. The storage module **150** may also provide for validating authenticity of stored information; for example, the storage module **150** may be configured to cryptographically sign stored information.

The coordination module **160** may be configured to coordinate collision detection operations with other entities, such as the vehicles **103**, **104**. Coordination may comprise cooperative sensor configuration, sharing sensor data, sharing processed information, and so on. The coordination may be established on an ad-hoc basis (e.g., one or more vehicles **102**, **103**, and/or **104** may broadcast portions of the collision detection model **122** and/or other collision detection data), may be established in response to a request (e.g., a vehicle-to-vehicle coordination), or the like. In some embodiments, collision detection system coordination may be predicated on a payment, reciprocal sharing, or other exchange.

FIG. **2**A is a block diagram **200** depicting another embodiment of a collision detection system **101**. An area **225** may be inaccessible to the sensing system **110** of the collision detection system **101**. In the FIG. **2**A example, the area **225** is inaccessible due to position of the vehicles **103** and **144**. In response, the coordination module **160** may be configured to transmit a request **223** for sensor data pertaining to the area **225** (via the communication module **130**).

In some embodiments, the request **223** may be transmitted in response to other conditions. For example, the collision detection system **101** may not include a sensing system **110** and/or the sensing system **110** may be inactive (e.g., may be inoperative). The collision detection system **101** may, therefore, rely on sensor data from other sources, such as the vehicle **103**, to detect potential collisions. Alternatively, the collision detection system **101** may request sensor data from all available sources, including sensor data pertaining to areas from which the sensing system **110** is capable of acquiring sensor data. The collision detection system **101** may use redundant sensor data to validate and/or refine the sensor data acquired by the sensing system **110**.

The request **223** may comprise a request for sensor data pertaining to a particular area **225** and/or may comprise a request for all available sensor data. The request **223** may be directed to a particular entity (e.g., vehicle **103**) and/or may be broadcast to any source capable of satisfying the request **223**. Accordingly, in some embodiments, the request **223** may comprise establishing a communication link with the vehicle **103** (e.g., discovering the vehicle **103** via one or more network discovery broadcast messages, performing a handshake protocol, and so on).

The request **223** may comprise an offer of compensation in exchange for access to the requested sensor data. Accordingly, the request **223** may comprise a negotiation to establish an acceptable exchange (e.g., an acceptable payment, reciprocal data sharing, or the like). The negotiation may occur automatically in accordance with pre-determined policy, rules, and/or thresholds stored on the persistent, machine-readable storage medium **152**. Alternatively, the negotiation may comprise interacting with occupant(s) of the vehicles **102**, **103** and/or other entities (e.g., via the network **130**). For example, the vehicles **102**, **103** may be associated with organizations that have agreed to share collision detection data (e.g., an automobile association, insurance carrier, or the like). In some embodiments, the sensing system **113** of the vehicle **103** may be configured to broadcast the sensor data automatically, such that an explicit request **233** for the sensor data is not required.

The vehicle **103** may provide sensor data **227**, which may be received via the communication module **130**. The sensor data **227** may comprise sensor data acquired by the sensing system **113** of the vehicle (or acquired by one or more other vehicles or sources (not shown)). The collision detection system **101** may use the sensor data **227** to detect potential collisions, as described above. For example, the processing module **120** may generate a collision detection module that incorporates the sensor data **227**. In some embodiments, the vehicle **103** may provide auxiliary data **229** in addition to (and/or in place of) the sensor data **227**. The auxiliary data **229** may comprise processed sensor data, such as "self-knowledge" pertaining to the vehicle **103**, which may include, but is not limited to: identification, vehicle size, vehicle orientation, vehicle weight, position (absolute position or position relative to the vehicle **102**), velocity (e.g., a speedometer reading), acceleration (e.g., accelerometer readings), a time reference (e.g., a time synchronization signal), and so on. The processing module **120** may use the auxiliary data **229** to translate the sensor data **227** into a frame of reference of the vehicle **102** or other suitable frame of reference, as described above. Translating the sensor data **227** may further comprise aligning sensor data (e.g., aligning the sensor data **227** with sensor data acquired by the sensing system **110**). Aligning may comprise time shifting and/or time aligning the sensor data **227** relative to other sensor data samples and/or streams. As such, aligning the sensor data **227** may comprise aligning time-stamped sensor data, extrapolating sensor data (e.g., extrapolating a position from velocity and/or orientation, extrapolating velocity from acceleration, and so on), time shifting sensor data, and so on.

In some embodiments, the coordination module **160** may be configured to provide collision detection data **222** to the vehicle **103**. The collision detection data **222** may include, but is not limited to: the collision detection model **122** (and/or a portion thereof), sensor data acquired by the sensing system **110**, information pertaining to potential collisions detected by the collision detection system **101**, auxiliary data pertaining to the vehicle **102**, and so on.

Accordingly, in some embodiments, the collision detection system **101** may be configured to aggregate sensor data from multiple sources (e.g., sensing system **110**, vehicle **103**, and so on), generate a collision detection model **122** using the sensor data (and/or auxiliary data, if any), and provide the collision detection model **122** to other vehicles **103**, **144** (by transmitting the collision detection data **222**). Accordingly, vehicles in a communication range of the vehicle **102** (communication range of the communication module **130**) may take advantage of the collision detection model **122**. In some embodiments, one or more vehicles may be configured to re-transmit and/or re-broadcast the collision detection data **222** to other vehicles, which may extend an effective communication range of the collision detection system **101** (e.g., as in an ad-hoc wireless network configuration).

In some embodiments, the collision detection system **101** may be configured to provide and/or store monitoring data **272** to one or more persistent storage systems, such as the network-accessible service **154**, persistent, machine-readable storage medium **152**, or the like. The monitoring data **272** may include, but is not limited to: collision detection data **222**, sensor data used by the collision detection system **101** (sensor information acquired using the sensing system **110**, acquired from other sources, such as the vehicle **103**, and so on), the collision detection model **122**, information pertaining to potential collisions detected by the collision detection system **101**, collision alerts generated by the collision detection system **101**, diagnostic information pertaining to the vehicle **102** and/or other vehicles **103**, **144**, operating conditions, location (e.g., GPS coordinates), time information, and so on. The diagnostic information may include, but is not limited to: indications of whether other vehicles **103**, **144** comprise collision detection systems and/or are configured to coordinate collision detection with the collision detection system **101**, indications of whether other vehicles **103**, **144** are capable of communicating with the collision detection system **103** (e.g., capable of receiving collision detection data), actions taken in response to detecting a potential collision and/or alerting other vehicles to a potential collision, and so on.

The monitoring data **272** may be used to reconstruct peri-collisional conditions, such as the kinematics of vehicles **102**, **103**, and/or **144** before, during, and/or after a collision. The monitoring data **272** may further include information pertaining to the actions (if any) taken by the vehicles **102**, **103**, and/or **144** in response to detecting a potential collision (e.g., operator control inputs, automatic collision avoidance actions, etc.), and so on. In some embodiments, the monitoring data **272** may comprise timestamps and/or other auxiliary data to allow a location and/or time of the monitoring data **272** to be determined.

The monitoring data **272** may further comprise vehicle identifying information (e.g., information identifying the vehicle **102**, **103**, and/or **144**), such as a vehicle identification number (VIN), license plate information, registration information, vehicle make, model, and color designations, and so on. The vehicle identifier(s) may be derived from sensor data acquired by the sensing system **110** (or other vehicle **103**) and/or may be received as auxiliary data from one or more other vehicles; for instance the vehicles **102**, **103**, and/or **144** may be configured to provide identifying information to other vehicles (e.g., broadcast identifying information via a network, near-field communication, BLUETOOTH®, or the like). In other examples, one or more of the vehicles **102**, **103**, and/or **144** may comprise a Radio Frequency Identifier (RFID), which may be interrogated by an RFID reader of the sensing system **110**. Other objects may comprise identifying information, such as pedestrians, buildings, road features (e.g., street signs, traffic lights, etc.), and so on. These objects may be configured to provide identifying information to one or more of the vehicles **102**, **103**, and/or **144**, which may incorporate the identifying information into the collision detection model **122** and/or monitoring data **272**. For example, a person may carry an item that is configured to broadcast and/or provide identifying information (e.g., via RFID), such as the person's name, address, allergies, emergency contact information, insurance carrier, license number, and so on. Similarly, road features may be configured to provide identifying information. For example, a traffic signal may be configured to broadcast location information (e.g., the location of the signal), state information (e.g., red light, green light, etc.), and so on.

As described above, in some embodiments, the monitoring data **272** may be secured to prevent the monitoring data **272** from being modified; for example, the collision detection data **272** may comprise a digital signature, may be encrypted, or the like. The monitoring data **272** may be secured, such that the authenticity and/or source of the monitoring data **272** may be verified.

In some embodiments, a network-accessible service **154** may be configured to store monitoring data **272** from a plurality of different vehicles. The collision construction data **272** may be received via the network **132** and/or extracted from persistent, machine-readable storage media **152** of a vehicle (e.g., vehicle **102**). The network-accessible service may index and/or arrange the monitoring data **272** by time, location, vehicle identity, and so on. The network-accessible service **154** may provide monitoring data **272** to a requester based upon a selection criteria (e.g., time, location, identity, etc.). In some embodiments, the network-accessible service **154** may provide consideration for the monitoring data **272** (e.g., a payment, reciprocal access, etc.).

In some examples, the collision detection data **222** may be provided to an emergency services entity in response to detecting a collision. The collision detection data **222** may be used to determine and/or estimate collision kinematics (e.g., impact velocity, impact vectors, etc.), which may be used to estimate forces involved in the collision, probable injury conditions, the final resting location of vehicles (or vehicle occupants) involved in the collision, and so on.

The collision detection system **101** may be further configured to respond to requests for collision detection data **222**. In some embodiments, the collision detection system **101** may provide sensor data acquired by the sensing system to one or more other vehicles (e.g., vehicle **103**) in response to a request, as described above. In another example, the collision detection system **101** may provide the collision detection model **122** (and/or a portion thereof) to other vehicles and/or entities. The collision detection system **101** may be configured to store collision detection data, such as the collision detection model **122** and/or acquired sensor data to a network-accessible service **154**, emergency services entity, traffic control entity, or the like, via the network **132**.

FIG. **2**B is a block diagram **201** depicting another embodiment of a collision detection system **101**. In some embodiments, the collision detection system **101** may be configured to combine sensor data to determine different components of object kinematics (e.g., different components of velocity, acceleration, etc.). As described above, kinematic information may be expressed as vector quantities in a particular coordinate system and/or frame of reference (e.g., Cartesian coordinate system, polar coordinate system, or the like). The quantities may be relative to a particular frame of reference (e.g., vehicle **102**, **103**, etc.). Vector quantities may be deconstructed into one or more component quantities; in a Cartesian coordinate system, a vector quantity may comprise x, y, and/or z component quantities; in a polar coordinate system, a vector quantity may comprise r, theta (range and angle), and/or z component quantities; and so on. In some embodiments, the ability of a sensing system to determine particular components of object kinematics may depend, inter alia, upon the position and/or orientation of the sensing system relative to the object. For example, a Doppler radar may be capable of acquiring data pertaining to certain components of object kinematics, but not others, depending upon an orientation and/or position of the Doppler radar relative to the object.

As illustrated in FIG. **2**B, the sensing system **110** of the collision detection system **101** may be positioned and/or oriented relative to the vehicle **204**, such that the sensing system **110** is capable of acquiring object kinematics pertaining to component **260** (e.g., the "x axis" component, which corresponds to "side-to-side" range, velocity, and so on). The sensing system **110**, however, may not be capable of determining component **261** (e.g., the "y axis" component, which corresponds to "forward" range, velocity, and so on). For example, the sensing system **110** may comprise a Doppler radar, which is effective at determining component **260**, but not component **261**. Another sensing system **213** of the vehicle **203** may be capable of acquiring object kinematics pertaining to component **261**, but not component **260**.

The coordination module **160** of the collision detection system **101** may be configured to share sensor data **221** with the vehicle **203**, which may comprise providing sensor data acquired by the sensing system **110** (pertaining to component **260**) and/or receiving sensor data acquired by the sensing system **213** of the vehicle **203** (pertaining to component **261**). The coordination module **160** may be configured to request access to sensor data acquired by the vehicle **203**, as described above. The coordination module **160** may be further configured to provide access to sensor data acquired by the sensing system **110**, as described above (e.g., in exchange for access to the sensor data acquired by the vehicle **203**, a payment, or the like). The sensor data **221** may be shared via the communication module **130**, as described above.

The processing module **120** of the collision detection system **101** may "fuse" the sensor data acquired by the sensing system **110** (and pertaining to component **260**) with the sensor data acquired from the vehicle **203** (and pertaining to component **261**) to develop a more complete and accurate model of the kinematics of the vehicle **204**. Fusing the sensor data may comprise translating the sensor data into a common coordinate system and/or frame of reference, weighting the sensor data, and so on. The sensor data may be combined to determine object kinematics and/or may be used to refine other sensor data using component analysis or other suitable processing techniques. In the FIG. **2**B example, fusing the sensor data may comprise using the sensor data acquired by the sensing system **110** to determine a component (component **260**) of objects kinematics (e.g., side-to-side kinematic characteristics) and using the sensor data acquired by the vehicle **203** to determine object kinematics in component **261** (e.g., forward kinematic characteristics). Fusing may further comprise combining range and/or angle information of the sensor data **221** to determine and/or refine a position of the vehicle **204** relative to the vehicle **102** and/or **203**, which may comprise triangulating range and/or angle information of the sensor data. Similarly, fusing the sensor data may comprise determining object size, orientation, angular extent, angle-dependent range, and so on. For example, range information from different sensors may be used to determine position and/or angular orientation (e.g., using intersecting range radii analysis).

Combining the sensor data may further comprise weighting the sensor data. Sensor data may be weighted in accordance with the accuracy of the data (e.g., signal-to-noise ratio), sensor data orientation and/or position relative to a particular object, and so on.

The combination of sensor data may be determined, inter alia, upon a relative position and/or orientation of the sensing system **110** and/or vehicle **203**, as described above. As would be appreciated by one of skill in the art, other sensor orientations may result in different types of sensor data combinations. FIG. **2**C is a block diagram of another embodiment of a collision detection system. In the FIG. **2**C example, the sensing system **110** and vehicle **203** are at different orientations relative to the vehicle **204**. As a result, the sensor data may be fused in a different way. For example, the component **260** may be determined by a combination of the sensor data acquired by the sensing system **110** and the sensor data acquired by the vehicle **203** (as opposed to primarily sensor data acquired by the sensing system **110**, as in the FIG. **2**B example). The relative contributions of the different sensor data may be based, inter alia, upon the relative orientation (e.g., angles **262**, **263**) of the vehicles **102** and **203**. The combination may update dynamically in response to changes in the relative position and/or orientation of the vehicles **102**, **203**, and/or **204** (e.g., changes to the angles **262** and/or **263**).

In some embodiments, fusing sensor data may further comprise weighting the sensor data. The relative weights of sensor data may correspond to a signal-to-noise ratio of the sensor data, a position and/or orientation of the sensor data to a particular object, and so on. Accordingly, weights may be applied on a per-object basis. Referring back to the FIG. **2**B example, weights for the sensor data acquired by sensing system **110** for component **260** may be relatively high (due to the sensing system **110** being ideally positioned to measure component **260**), and the weights for the sensor data for component **261** may be low (due to the poor position of the sensing system **110** for measuring component **261**).

FIG. **3** is a flow diagram of one embodiment of a method **300** for coordinating collision detection. The method **300** may be implemented by a collision detection system, as described herein. In some embodiments, the method **300** may be embodied as instructions stored on a persistent, machine-readable storage medium (e.g., persistent, machine-readable storage medium **152**). The instructions may be configured to cause a processor to perform one or more of the steps of the method **300**.

At step **310**, the method **300** starts and is initialized, which may comprise loading instructions from a persistent, machine-readable storage medium and accessing and/or initializing resources, such as a sensing system **110**, processing module **120**, communication module **130**, coordination module **160**, and so on.

Step **320** may comprise acquiring sensor data at a vehicle **102**. The sensor data of step **320** may be acquired from a source that is external to the vehicle **102**, such as another vehicle (e.g., sensor data acquired by the sensing system **113** of vehicle **103**). The sensor data may be acquired in response to a request and/or negotiation, as described above. Alternatively, the sensor data may be acquired without a request (e.g., the sensor data acquired at step **320** may be broadcast from a source, as described above). In some embodiments, step **320** may further comprise receiving auxiliary data from a source of the sensor data. The auxiliary data may comprise a "self-knowledge" data pertaining to the source of the sensor data, such as size, weight, orientation, position, kinematics, and so on.

In some embodiments, step **320** may comprise fusing the sensor data acquired at step **320** with other sensor data acquired from other sources (e.g., the sensing system **110** of the collision detection system **101**). Accordingly, step **330** may comprise translating sensor data into a suitable coordinate system and/or frame of reference (e.g., using auxiliary data of the vehicle **102** and/or the source(s) of the sensor data). Fusing the sensor data may further comprise weighting and/or aligning the sensor data, which may comprise time shifting the sensor data, extrapolating the sensor data, or the like, as described above.

Step **330** may comprise generating a collision detection model using the sensor data acquired at step **320**. Generating the collision detection model may comprise determining object kinematics using the sensor data, such as object position, velocity, acceleration, orientation, and so on. Generating the collision detection model may further comprise determining and/or estimating object size, weight, and so on. Step **330** may comprise combining sensor data to determine and/or refine one or more component quantities. For example, step **330** may comprise triangulating range and/or angle information in the sensor data to determine object position, applying intersecting range radii analysis to determine angular orientation, fusing sensor data to determine different components of object kinematics, and so on.

Step **330** may further comprise translating the collision detection model into a suitable coordinate system and/or frame of reference. For example, step **330** may comprise generating a collision detection model in a particular frame of reference (e.g., relative to the vehicle **102**). Step **330** may further comprise translating the collision detection model into other coordinate systems and/or frames of reference. For example, step **330** may comprise translating the collision detection model into the frame of reference of another vehicle (e.g., vehicle **103**). The translations step **330** (and/or step **320**) may be based upon a position, velocity, acceleration, and/or orientation of the source(s) of the sensor data acquired at step **320** and/or a position, velocity, acceleration, and/or orientation of a particular frame of reference.

In some embodiments, step **330** may further comprise detecting a potential collision using the collision detection model and/or taking one or more actions in response to detecting the potential collision, as described above. The method **300** ends at step **340** until additional sensor data is acquired at step **320**.

FIG. **4** is a flow diagram of another embodiment of a method **400** for coordinating collision detection. At step **410** the method **400** starts and is initialized as described above.

Step **412** may comprise acquiring sensor data using a vehicle sensing system **110**, as described above. The sensor data of step **412** may be acquired using one or more different types of sensing systems, comprising any number of different sensors.

Step **414** may comprise requesting sensor data from an external entity (e.g., another vehicle **103**). The request of step **414** may be made in response to determining that the sensor data of step **412** fails to capture a particular area (e.g., area **125**, **225**), fails to capture certain kinematic components of an object (e.g., a particular component **261** of object kinematics), and so on. Alternatively, the request of step **414** may be made regardless of the nature of the sensor data acquired at step **412**. The requested sensor data may be used to augment and/or refine the sensor data acquired at step **412** and/or sensor data acquired from other sources.

In some embodiments, the request of step **414** may be transmitted to a particular entity (e.g., a particular vehicle **103**). Accordingly, step **414** may comprise establishing communication with the entity, which may comprise discovering the entity (e.g., via one or more broadcast messages), establishing a communication link with the entity, and so on. Alternatively, the request of step **414** may not be directed to any particular entity, but may be broadcast to any entity capable of providing sensor data.

The request may identify a particular area of interest (e.g., area **125**, **225**). The area of interest may be specified relative to the vehicle **102** (the requester) and/or another frame of reference. Accordingly, step **414** may comprise translating information pertaining to the request into another coordinate system and/or frame of reference, as described above. Alternatively, or in addition, the request may identify an object of interest and/or request data acquired at a particular orientation and/or position with respect to an object. The requested data may be used to determine and/or refine kinematic components that are not available to the sensing system **110** of the vehicle **102**, as described above.

The request may comprise an offer in exchange for access to the sensor data. The offer may comprise a payment, bid, reciprocal access, collision detection data, or other consideration. Accordingly, in some embodiments, step **414** may comprise negotiating an acceptable exchange using one or more of: pre-determined policy, rules, thresholds, or the like. Step **414** may further comprise receiving acceptance from the requester, the source of the sensor data, and/or another entity (e.g., an association, insurer, or the like), as described above.

Step **422** may comprise acquiring the requested sensor data using the communication module **130**, as described above. Although method **400** depicts a request step **414**, in some embodiments, the request may **414** may not be required. For example, in some embodiments, the sensor data may be made freely available (e.g., broadcast), such that the sensor data may be acquired at step **422** without an explicit request. Step **422** may comprise translating the acquired sensor data, as described above.

Step **432** may comprise generating a collision detection model using the sensor data acquired using the vehicle sensing system **110** and/or the sensor data acquired from the other vehicle at step **422**. Generating the collision detection model may comprise fusing sensor data (e.g., combining the sensor data), determining object kinematics using the fused sensor data, and so on. Generating the collision detection model may further comprise translating the collision detection model into one or more suitable coordinate systems and/or frames of reference. Step **432** may further comprise detecting potential collisions using the collision detection model, which may comprise identifying objects involved in the potential collision, determining a time to the potential collision, determining collision avoidance actions and/or instructions, issuing one or more alerts and/or notifications, and so on.

Step **434** may comprise providing access to collision detection data to one or more other entities (e.g., the source of the sensor data acquired at step **422**). Step **434** may comprise providing a portion of the collision detection model generated at step **432** to one or more other vehicles, providing one or more collision detection alerts to other vehicles, providing sensor data to one or more other vehicles, and the like. Step **434** may comprise transmitting the collision detection data to a particular vehicle and/or broadcasting the collision detection data. The collision detection data may comprise auxiliary information, such as a position and/or kinematics of the vehicle **102**, time information, and so on, which may allow recipients to translate the collision detection data into other coordinate systems and/or frames of reference. In some embodiments, step **434** may comprise providing monitoring data **272** to a network-accessible service **154**, storing the monitoring data **272** on a persistent, machine-readable storage media **152**, and the like.

The method **400** ends at step **440** until additional sensor data is acquired.

Although FIG. **4** depicts steps in a particular sequence, the disclosure is not limited in this regard; for example, the vehicle **102** may acquire sensor data using the sensing system **110** while concurrently receiving sensor data from another

entity at step **422**, generating the collision detection model at step **432**, and/or providing access to collision detection data at step **434**.

In some embodiments, the collision detection system **101** may be further configured to operate the sensing system **110** in cooperation with sensing systems of other vehicles. The cooperative operation may comprise forming a multistatic sensor comprising the sensing system **110** and one or more sensing systems of other land vehicles. As used herein, a "multistatic sensor" refers to a sensor comprising two or more spatially diverse sensing systems, which may be configured to operate cooperatively. For example, one or more of the sensing systems may be configured to emit respective detection signals, which may be received by receivers of one or more of the sensing systems. Sensor cooperation may comprise coordinating one or more detection signals emitted by one or more sensing systems (e.g., beamforming, forming a phased array, or the like).

FIG. **5**A depicts one embodiment **500** of a collision detection system **101** configured to coordinate sensor operation with other sensing systems. In example **500**, the sensing system **110** comprises a detection signal emitter **512** and receiver **514**. The emitter **512** may comprise a radar transmitter, EO emitter, acoustic emitter, ultrasonic emitters, or the like. The receiver **514** may be configured to detect one or more returned detection signals. Accordingly, the receiver **514** may comprise one or more antennas, EO detectors, acoustic receivers, ultrasonic receivers, or the like.

The collision detection system **101** may be configured to coordinate operation of the sensing system **110** with sensing systems of other vehicles (e.g., sensing systems **570** and/or **580**). Coordination may comprise forming a multistatic sensor comprising the sensing system **110** and one or more of the sensing systems **570** and/or **580**.

In some embodiments, the collision detection system **101** may coordinate with another sensing system to acquire information pertaining to an object that is outside of a detection range of the sensing system **110** and/or to augment sensor data obtained by the sensing system **110**. As used herein, an object that is "outside of the detection range of the sensing system **110**" refers to any object about which the sensing system **110** cannot reliably obtain information, which may include, but is not limited to: objects beyond a detection range of the sensing system **110**, objects obscured or blocked by other objects, objects at a position and/or orientation that prevents the sensing system **110** from determining one or more kinematic characteristics of the object (e.g., as depicted in FIG. **2**B), and so on. As such, an object for which sensor data is not sufficiently reliable and/or from which one or more kinematic characteristics cannot be reliably derived is deemed to be outside of the detection range of the sensing system **110**. As used herein, sensor data that is "sufficiently reliable" refers to sensor data conforming to one or more reliability criteria, which may include, but are not limited to: a signal-to-noise threshold, a signal strength threshold, a resolution (e.g., accuracy) threshold, or the like.

The FIG. **5**A example depicts a vehicle **522** that may be outside of the detection range of the sensing system **110**; a vehicle **520** may "block" a detection signal of the emitter **512**, such that the receiver **514** cannot reliably obtain data pertaining to the vehicle **522**. In response to determining that the vehicle **522** is outside of the detection range of the sensing system **110**, the collision detection system **101** may be configured to request sensor data pertaining to the vehicle **522** from one or more other vehicles (e.g., vehicle **505**), as described above. The request(s) may be generated in response to determining that the vehicle **522** (or other region) is within a detection range and/or envelope of a sensing system of one or more of the other vehicles. Alternatively, or in addition, the coordination module **160** of the collision detection system **101** may be configured to request access to the sensing system **580** of the vehicle **505**. Requesting access may comprise requesting that the sensing system **580** operate in coordination with the sensing system **110**. In the FIG. **5**A example, the coordination module **160** may be configured to form a multistatic sensor comprising the sensing system **110** of the first land vehicle **102** and the sensing system **580** of the land vehicle **505**. The multistatic sensor may comprise a detection signal emitter **582** of the sensing system **580** and the detection signal receiver **514** of the sensing system **110**. In response to the request, the emitter **582** may be configured to emit a detection signal **587** that is configured to be received by the receiver **514** of the sensing system **110**. The detection signal **587** may be received in place of or in addition to a detection signal emitted by the emitter **512** of the sensing system **110** (a detection signal emitted by the emitter **512** is not shown in FIG. **5**A to avoid obscuring the details of the embodiments). In addition, the collision detection system **101** may acquire auxiliary data from the vehicle **505**, which may include, but is not limited to: orientation, position, velocity, acceleration, and so on of the vehicle **505** relative to the vehicle **102**; a time synchronization signal; and so on. The processing module **120** may use the auxiliary data to interpret the received detection signal **587**, which may comprise translating the detection signal **587** into a frame of reference of the vehicle **102**, and so on, as described above.

As described above, coordinating sensor operation may further comprise the sensing system **110** generating one or more detection signals configured to be received by one or more other sensing systems **570** and/or **580**. For example, the emitter **512** may be configured to transmit a detection signal (not shown) toward the vehicle **522**; the detection signal may be received by a receiver **584** of the sensing system **580** and may provide information pertaining to the vehicle **522**. The sensing system **580** may fuse sensor data received in response to self-emitted detection signal(s) with the sensor data received in response to the detection signal emitted by the vehicle **102**, as described above. The multistatic sensor may, therefore, comprise emitters **512**, **582** and receivers **514**, **584** of both vehicles **102** and **505**.

As described above, coordinating sensor operation may comprise forming a multistatic sensor and/or generating one or more detection signals configured to acquire information pertaining to one or more objects outside of the detection range of one or more sensing systems. Accordingly, coordinating sensor operation may comprise directing one or more detection signals in a pre-determined direction and/or coordinating two or more detection signals, which may include, but is not limited to: beamforming, forming and/or configuring a phased array, or the like.

The coordination module **160** may be configured to coordinate sensor operation to augment and/or improve data acquisition for one or more objects. For example, the coordination module **160** may request the sensing system **570** to generate a detection signal **575**, which may be used to acquire more accurate sensor data pertaining to the vehicle **520**; in the FIG. **5**A example, a detection signal emitted by the sensing system **110** toward the vehicle **520** (not shown) may be partially obscured by another vehicle **521**. In response to the request, the sensing system **570** may configure an emitter **572** to transmit the detection signal **575**, which may be configured to acquire information pertaining to the vehicle **520** and be detected by the receiver **514** of the sensing system **110**. As described above, the coordination may further comprise acquiring auxiliary data from the vehicle **504**, which may allow the collision detection system **101** to process the detection signal **575**, as described above.

The coordination module **160** may be further configured to adapt detection signals generated by the emitter **512** in cooperation with other sensing systems **570** and/or **580**. In some embodiments, the coordination module **160** may configure the emitter **512** in response to a request from one or more other sensing systems (e.g., a request to direct a detection signal at a particular object and/or region). FIG. **5**B depicts another embodiment **501** of a collision detection system **101** configured to coordinate sensor operation with other sensing systems.

In the FIG. **5**B example, the sensing system **101** may have a relatively unobstructed view of vehicles **530** and **531**. However, the sensing system **580** may be obstructed by vehicles **532** and/or **520**. The collision detection system **101** may receive a request to coordinate sensor operation via the communication module **130**. The collision detection system **101** may configure the sensing system **110** in accordance with the request, which may comprise emitting one or more detection signals **515** and **517**; the signals **515** and **517** may be configured to acquire kinematic data pertaining to the vehicles **530** and/or **531** and may be configured to be detected by the receiver **584** of the sensing system **580**. Emitting the detection signals **515** and/or **517** may comprise emitting a plurality of separate detection signals, beamforming one or more detection signals of the emitter **512**, or the like. The coordination module **160** may be further configured to transmit auxiliary data to the sensing system **580** by way of the communication module **130**, which may allow the sensing system **580** to translate the received detection signal(s) **515** and/or **517** into a frame of reference of the sensing system **580**, as described above.

Although FIGS. **5**A and **5**B depict detection signals **575**, **585**, **587**, **515**, and **517** as "point sources," the disclosure is not limited in this regard. The detection signals disclosed herein may comprise a plurality of detection signals and/or detection signal coverage ranges. Moreover, although FIGS. **5**A and **5**B depict a sensing system **110** that comprises both a detection signal emitter **512** and receiver **514**, the disclosure is not limited in this regard. In some embodiments, for example, the sensing system **110** may be passive, and as such, may include a receiver **514** but not an emitter **512** (and/or the detection system emitter **512** may be deactivated). Accordingly, the sensing system **110** may acquire sensor data passively and/or in response to detection signals transmitted by other sensing systems, such as the sensing systems **570** and **580** described above. Alternatively, the sensing system **110** may be active and, as such, may include a detection signal emitter **512** but not a receiver **514** (and/or the receiver **514** may be deactivated). Accordingly, the sensing system **110** may acquire sensor data from other sensing systems (e.g., sensing systems **570** and/or **580**) in response to detection signal(s) emitted thereby.

FIG. **6** depicts another embodiment **600** of a collision detection system **101** configured to coordinate sensor operation and/or share sensor data. As illustrated in FIG. **6**, the sensing system **110** may be capable of acquiring sensor data pertaining to vehicles **620**, **630** and, to a limited extent, vehicle **631**; however, vehicle **632** may be out of the detection range of the sensing system **110** due to, inter alia, the vehicle **620**. Another vehicle **604** may comprise a sensing system **570** that is capable of acquiring sensor data pertaining to the vehicles **620**, **632** and, to a limited extent, vehicle **631**. The vehicle **630** may be outside of the detection range of the sensing system **570**.

The coordination module **160** may be configured to coordinate operation of the sensing systems **110** and **570**. The coordination may comprise configuring the sensing systems **110** and **570** to acquire sensor data pertaining to regions (and/or objects) within the respective detection ranges thereof, and to rely on the other sensing system **110** or **570** for sensor data pertaining to objects and/or regions outside of the respective detection ranges thereof.

For instance, in the FIG. **6** example, the coordination module **160** may configure the sensing system **110** to acquire sensor data pertaining to region **619**, which may comprise configuring the emitter **512** to emit detection signal(s) that are adapted to acquire information pertaining to objects in the region **619**. The configuration may comprise beamforming, forming a phased array, directing and/or focusing one or more detection beams, or the like, as described above. Accordingly, the coordination may comprise configuring the sensing system **110** to acquire sensor data pertaining to areas and/or objects (e.g., vehicle **630**) that are outside of the detection range of the sensing system **570**. As a result, the detection signals of the sensing system **110** may be directed away from other regions and/or areas (e.g., region **679**).

The coordination module **160** may be further configured to request that the sensing system **570** acquire sensor data pertaining to the region **679** (e.g., the vehicle **632**). The request may identify the region **679** in a frame of reference of the vehicle **604**, as described above. In response, the sensing system **570** may configure the emitter **572** to acquire sensor data pertaining to the region **679**, as described above (e.g., directing and/or focusing detection signals to the region **679**).

The coordination module **160** may be further configured to provide sensor data pertaining to the region **619** (and/or object **630**) to the vehicle **604** and/or to receive sensor data pertaining to the region **679** (and/or object **632**) from the vehicle **604** by use of the communication module **130**. The coordination may further comprise communicating auxiliary data pertaining to the vehicles **102** and **604**, such as position, velocity, acceleration, orientation, and so on, as described above.

In some embodiments, coordination may further comprise forming a multistatic sensor comprising the sensing system **110** and the sensing system **570**. Forming the multistatic sensor may comprise configuring the emitter **512** and/or **572** to direct detection signals to particular objects and/or regions of interest. In the FIG. **6** example, the multistatic sensor may be configured to direct detection signals to the vehicle **631**. As described above, neither sensing system **110** nor **570** may be capable of acquiring high-quality data pertaining to the vehicle **631** (e.g., due to vehicle obstructions). Forming the multistatic sensor may allow the sensing system **570** and/or **110** to acquire higher-quality data. For example, the emitters **572** and **512** may configure the phase and/or amplitude of the detection signals emitted thereby, such that detection signals emitted by the emitter **572** pertaining to the vehicle **631** are detected by the receiver **514** and detection signals emitted by the emitter **512** pertaining to the vehicle **631** are detected by the receiver **574**. The sensor data acquired by the receivers **574** and **514** may be fused to determine a more accurate and/or complete model of the kinematics of the vehicle **631**. As described above, fusing the sensor data may comprise translating the sensor data between frames of reference of the vehicles **102** and/or **604**. As such, the coordination may comprise exchanging auxiliary data, as described above.

The coordination module **160** may be configured to request configuration changes in response to detecting the sensing system **570** in communication range of the communication module **130**. Upon establishing communication, the coordination module **160** may be configured to coordinate operation of the sensing system **110** with the sensing system **570**, as described above. Moreover, as additional vehicle sensing systems are discovered, they may be included in the coordination (e.g., to form a multistatic sensor comprising three or more sensing systems). Alternatively, the coordination module **160** may be configured to request coordinated operation as needed. For example, the coordination module **160** may be configured to coordinate sensing system operation in response to determining that one or more regions and/or objects are outside of the detection range of the sensing system **110** (e.g., are obscured by other objects).

In some embodiments, the coordination module **160** may be configured to respond to requests to coordinate with other sensing systems (e.g., a request from the sensing system **570**). For example, sensing system **570** may initiate a request to coordinate sensor operation and, in response, the coordination module **160** may configure the sensing system **110** in accordance with the request. As described above, a request to coordinate sensor operation may comprise one or more offers, such as a payment, bid, offer for reciprocal data access, access to collision detection data, and so on.

FIG. **7** depicts another example **700** of a collision detection system **101** configured to coordinate sensor operation and/or share sensor data. As described above, the coordination module **160** may be configured to coordinate sensor operation in response to detecting other sensing systems in a communication range of the communication module **130**. In response to detecting one or more other sensing systems, the coordination module **160** may be configured to coordinate sensor operation, which may comprise forming a multistatic sensor, configuring detection signal(s) of the other sensing system(s), exchanging sensor data, exchanging auxiliary data, and so on.

FIG. **7** depicts one example of an ad hoc multistatic sensor comprising the sensing systems **110**, **570**, and **580**. As other vehicles comprising other sensing systems (not shown) are detected, the coordination module **160** may coordinate with those sensing systems to augment the multistatic sensor. The multistatic sensor may comprise a plurality of emitters **512**, **572**, and/or **582** and/or a plurality of receivers **514**, **574**, and/or **584**. The coordination module **160** may configure the emitters **512**, **572**, and/or **582** to direct detection signals emitted thereby to particular regions and/or objects of interest, as described above. The coordination may comprise coordinating a phase, amplitude, and/or timing of detection signals emitted by the emitters **512**, **572**, and/or **582** (e.g., using beamforming and/or phased array techniques). The coordination may further comprise coordinating the receivers **514**, **574**, and/or **584** to detect particular detection signals (e.g., form a phased array of receivers and/or antennas). Accordingly, the multistatic sensor formed from the sensing systems **110**, **570**, and/or **580** may comprise an arbitrary number of emitters and an arbitrary number of receivers (e.g., N emitters and M receivers).

The coordination module **160** may be configured to form a multistatic radar configured to acquire sensor data from various different points of view and/or orientations with respect to one or more objects. For example, each of the sensing systems **110**, **570**, and **580** may be configured to acquire sensor data pertaining to the vehicle **721**. Detection signals emitted by the emitters **512**, **572**, and/or **582** may be detected by one or more of the receivers **514**, **574**, and/or **584**. The collision detection system **101** may fuse sensor data acquired by the receiver **514** with sensor data acquired by receivers **574** and/or **584** of the other sensing system **570** and/or **580**, as discussed above, to model the kinematics of the vehicle **721**. Fusing sensor data acquired in response to different detection signals transmitted from different positions and/or orientations relative to the vehicle **721** may allow the collision detection system **101** to obtain a more complete and/or accurate model of the vehicle **721**.

In some embodiments, the communication module **130** may be configured to extend the communication range of the collision detection system **101** using ad hoc networking mechanisms (e.g., ad hoc routing mechanisms). For example, the sensing system **580** may be outside of a direct communication range of the communication module **130**. As used herein, a "direct communication range" refers to a range at which the communication module **130** can communicate directly with another entity (e.g., entity-to-entity communication). The communication module **130** may be configured to route communication through one or more entities that are within direct communication range. For example, the collision detection system **101** may be configured to route communication to/from the sensing system **580** through the sensing system **570**.

FIG. **8** is a flow diagram of one embodiment of a method **800** for coordinating operation of a sensing system. At step **810** the method **800** may start and be initialized, as described above.

Step **820** may comprise generating a request to configure a sensing system of a second land vehicle. The request may be generated by and/or transmitted from a collision detection system **101** of a first land vehicle **102** (e.g., a coordination module **160** of the collision detection system **101**). The request may be generated and/or transmitted in response to the collision detection system **101** detecting the second land vehicle in communication range (direct or indirect, as described above), in response to the collision detection system **101** determining that a region and/or object is outside of a detection range of a sensing system **110** thereof, and/or determining that the object and/or region is inside of a detection range or envelope of the sensing system of the second land vehicle. Accordingly, the request to configure the sensing system of the second land vehicle may be made on an as-needed basis. The request may comprise an offer of compensation in exchange for configuring the sensing system. The offer may include, but is not limited to: a payment, a bid, reciprocal data access, and so on. Step **820** may further comprise receiving an offer (or counter offer), accepting the offer (s), and so on, as described above.

In some embodiments, configuring the sensing system at step **820** may comprise directing the sensing system to one or more specified regions and/or objects. Directing the sensing system at step **820** may comprise directing detection signals of the sensing system to the one or more regions and/or objects, which may comprise adapting phase, amplitude, timing, focus, or other characteristics of the detection signals emitted by the sensing system.

Step **820** may further comprise configuring the sensing system of the second land vehicle to operate in cooperation with one or more other sensing systems, which may comprise forming a multistatic sensor comprising at least a portion of the sensing system of the second land vehicle and at least a portion of one or more sensing systems of other land vehicles. The configuration of step **820** may, therefore, comprise a multistatic sensor configuration, which may include, but is not limited to: beamforming, forming a phased array, and so on.

Step **820** may further comprise configuring the sensing system of the second land vehicle to transmit sensor data to one or more other sensing systems and/or collision detection systems, such as the collision detection system **101** of the first land vehicle **102**. Transmitting the sensor data may comprise exchanging sensor data acquired by use of the sensing system of the second land vehicle, communicating auxiliary data pertaining to the second vehicle, communicating collision detection data (e.g., portions of the collision detection model **122**, collision detection alerts, and the like), and so on, as described above.

Step **830** may comprise generating a collision detection model using sensor data acquired by use of the sensing system of the second land vehicle (and as configured at step **820**). Step **830** may comprise receiving sensor data acquired by use of a receiver of the second sensing system and communicated to the collision detection system **101** via the communication module **130**. Alternatively, or in addition, step **830** may comprise a receiver **514** of the sensing system **110** detecting sensor data in response to one or more detection signals emitted by the sensing system of the second land vehicle. Step **830** may further comprise receiving and/or determining auxiliary data pertaining to the second land vehicle. Step **830** may further comprise translating sensor data into one or more other frames of reference and/or coordinate systems, providing collision detection data **222** to other sensing systems and/or vehicles, storing and/or transmitting monitoring data **272**, and so on, as described above. Step **830** may further comprise detecting potential collisions using the collision detection model, generating and/or transmitting one or more alerts in response to detecting potential collisions, taking one or more collision avoidance actions, and so on. Step **830** may further comprise providing portions of the collision detection model to one or more other vehicles, as described above. The method **800** ends at step **840**.

FIG. **9** is a flow diagram of one embodiment of a method **900** for coordinating operation of a sensing system. At step **910**, the method **900** may start and be initialized, as described above.

Step **920** may comprise configuring the sensing system **110** of the collision detection system **101** in response to a request. The request may comprise a request to coordinate operation of the sensing system **110** with one or more sensing systems of other land vehicles, and may be received by way of the communication module **130**. The request may comprise an offer of consideration in exchange for configuring the sensing system **110**. Step **920** may comprise accepting the offer, generating a counteroffer, or the like, as described above.

Step **920** may comprise configuring the sensing system **110** to coordinate operation with other sensing systems, which may include, but is not limited to: directing the sensing system **110** to a particular region and/or object, providing sensor data acquired by use of the sensing system **110** to one or more other vehicles, providing auxiliary data pertaining to the vehicle **102** to the one or more other vehicles, forming a multistatic sensor comprising the sensing system **110**, and the like. Accordingly, step **920** may comprise configuring detection signals generated by the emitter **512** of the sensing system **110** in cooperation with other sensing systems, which may include, but is not limited to: adapting phase, amplitude, timing, focus, or other characteristics of the detection signals, as described above. Step **920** may further comprise configuring a receiver **514** of the sensing system **110** to receive detection signals generated by the other sensing systems (e.g., to form a phased antenna array).

Step **930** may comprise generating a collision detection model using sensor data acquired by use of the sensing system as configured at step **920**. Step **930** may, therefore, comprise generating the collision model using sensor data acquired by use of two or more sensing systems that are operating in coordination per step **920**. Step **930** may comprise acquiring sensor data in response to one or more detection signals emitted by one or more other sensing systems, receiving sensor data acquired by use of one or more other sensing systems, receiving auxiliary data from one or more other sensing systems, and so on. Step **930** may further comprise detecting potential collisions using the collision detection model, generating and/or transmitting one or more alerts in response to detecting potential collisions, taking one or more collision avoidance actions, and so on. Step **930** may further comprise translating sensor data into one or more other frames of reference and/or coordinate systems, providing collision detection data **222** to other sensing systems and/or vehicles, storing and/or transmitting monitoring data **172**, and so on, as described above. The method **900** ends at step **940**.

In some embodiments, the collision detection system **101** may be configured to store and/or transmit monitoring data **272**, which as described above, may comprise data for reconstructing and/or modeling peri-collisional circumstances before, during, and/or after a collision. The monitoring data **272** may include, but is not limited to: the collision detection model **122** and/or portions thereof (e.g., object kinematic information), sensor data acquired by use of the sensing system **110**, sensor data acquired from other sources (e.g., other sensing systems), auxiliary data (e.g., orientation, position, velocity, acceleration, etc.) of the vehicle **102** and/or other vehicles, potential collisions detected by the collision detection system **101**, avoidance actions taken (if any) in response to detecting the potential collision, collision kinematics, post-collision kinematics, and so on.

FIG. **10** is a block diagram **1000** of one embodiment of a monitoring service **1040**. The monitoring service **1040** may operate on a computing device **1030**, which may comprise a processor **1032**, a memory **1034**, a communication module **1036**, and persistent storage **1038**, as described above. The monitoring service **1040** may be embodied as one or more machine-readable storage medium stored on a persistent storage medium (e.g., persistent storage **1038**). The instructions comprising the monitoring service **1040** may be configured for execution on the computing device **1030** (e.g., configured for execution on the processor **1032** of the computing device **1030**). Alternatively, or in addition, portions of the monitoring service **1040** (as well as the other modules and systems disclosed herein) may be implemented using machine elements, such as special purpose processors, ASICs, FPGAs, PALs, PLDs, PLAs, or the like.

An intake module **1042** may be configured to request and/or receive vehicle monitoring data **272** from collision detection systems **101**A-N of land vehicles **102**A-N. As described above, the monitoring data **272** may include, but is not limited to: collision detection data **222**, sensor data used by a collision detection system **101**A-N (sensor data acquired by the collision detection system **101**A-N, acquired from other sources, and so on), the collision detection model **122** (and/or portions thereof), information pertaining to potential collisions detected by a collision detection system **101**A-N, collision alerts generated by a collision detection system **101**A-N, diagnostic information pertaining to the vehicle **102**A-N, collision reconstruction data, object kinematics, vehicle operating conditions, auxiliary data (e.g., location time information, etc.), and so on.

In some embodiments, the monitoring data **272** may be received via the network **132** (through the communication module **1036** of the computing device **1030**). For example, and as described above, one or more of the collision detection systems **101**A-N (e.g., collision detection systems **101**A-C) may be configured to maintain and/or transmit monitoring data **272** during vehicle operation (e.g., in "real-time"). Alternatively, one or more of the collision detection systems **101**A-N may be configured to transmit monitoring data **272** periodically, intermittently, and/or in response to detecting a particular event or operating condition. For example, a collision detection system **101**A-N may be configured to transmit monitoring data **272** in response to detecting a vehicle operating in a particular way (e.g., speeding, driving erratically, or the like), detecting a particular vehicle, detecting a potential collision, detecting an actual collision, or the like. Alternatively, or in addition, one or more collision detection systems **101**A-N may be configured to transmit monitoring data **272** in response to a request from the monitoring service **1040**. Accordingly, the collision detection systems **101**A-N may be configured to "push" monitoring data **272** to the monitoring service **1040** and/or the monitoring service **1040** may be configured to "pull" monitoring data **272** from one or more of the collision detection systems **101**A-N.

As described above, a collision detection system **101**A-N may be configured to transmit monitoring data **272** intermittently. For example, the collision detection system **101**N may be configured to store monitoring data **272** on the storage module **150**N, which may be intermittently uploaded to the monitoring service **1040**. For example, monitoring data **272** may be uploaded when the communication module **130**N is activated, when the communication module **130**N is in communication with the network **132** (e.g., is in communication range of a wireless access point), or the like. In another example, stored monitoring data **272** may be accessed from the storage service **150**N by a computing device **1037**, which may be configured to transmit the monitoring data **272** to the monitoring service **1040**. The stored monitoring data **272** may be accessed when the vehicle **102**N is serviced, is in communication range of the computing device **1037**, may be accessed as part of a post-collision diagnostic, or the like. In some embodiments, the computing device **1037** may comprise a mobile communication device (e.g., cellular telephone), which may access the stored monitoring data **272** via a wireless communication interface (e.g., near-field communication (NFC), BLUETOOTH®, or the like).

The monitoring service **1040** may be configured to offer consideration for providing the monitoring data **272**. The consideration may comprise one or more of a payment, bid, reciprocal data access (e.g., access to stored monitoring data **1072**A-N, described below), or the like. The consideration may further comprise access to features of the monitoring service **1040**, such as access to collision alert(s) **1047** (described below), and so on.

Monitoring data **272** received at the monitoring service **1040** may be processed by an intake module **1042**. The intake module **1042** may be configured to process and/or store monitoring data entries **1072**A-N in a persistent storage **1054**. The intake module **1042** may be further configured to index the monitoring data **1072**A-N, by one or more index criteria, which may include, but are not limited to: time, location, vehicle identifier(s), detected collision(s), and/or other suitable criteria. The index criteria may be stored in respective index entries **1073**A-N. Alternatively, indexing criteria may be stored with the monitoring data entries **1072**A-N.

The intake module **1042** may be configured to extract and/or derive indexing criteria from received monitoring data **272**. For example, the monitoring data **272** may comprise a time synchronization signal, time stamp, or other timing data, from which time indexing criteria may be determined. Similarly, the monitoring data **272** may comprise auxiliary data (e.g., GPS coordinates), from which location indexing information may be determined. Accordingly, extracting indexing criteria may comprise extracting one or more data streams and/or data fields from the monitoring data **272** (e.g., extracting a time stamp and/or time synchronization signal, extracting location coordinates, and so on).

The monitoring data **272** may further comprise information from which indexing criteria may be derived. Deriving indexing criteria may comprise using the monitoring data **272** to determine indexing criteria. For example, vehicle identifier(s) may be derived from received monitoring data **272**, such as VIN codes, license plate information, vehicle RFID, imagery data (e.g., image(s) of vehicle license plates, etc.), and so on. Deriving indexing criteria may comprise determining a vehicle identifier from sensor data (e.g., an image in the monitoring data **272**), determining vehicle location from vehicle kinematics, and so on.

In some embodiments, the intake module **1042** may be configured to translate and/or normalize the monitoring data **272** (and/or indexing data extracted and/or derived therefrom). For example, the intake module **1042** may be configured to translate timing information into a suitable time zone, convert and/or translate location information (e.g., from GPS coordinates into another location reference and/or coordinate system), translate collision detection data, such as the collision detection model **122** and/or vehicle kinematic information into a different frame of reference and/or coordinate system, and so on, as described above.

In some embodiments, the intake module **1042** may be configured to augment the monitoring data **272**. For example, the intake module **1042** may be configured to combine monitoring data **272** pertaining to the same time and/or location (e.g., overlapping times and/or locations). The intake module **1042** may be configured to aggregate "overlapping" monitoring data **272**, which may comprise revising and/or refining portions of the monitoring data **272**.

The intake module **1042** may be further configured to authenticate monitoring data **272**, which may include, but is not limited to: verifying a credential of the monitoring data **272**, validating a signature on the monitoring data **272**, decrypting the monitoring data **272**, or the like. In some embodiments, monitoring data **272** that cannot be authenticated may be rejected (e.g., not included in the persistent storage **1054** and/or indexed as described above).

As described above, the intake module **1042** may be configured to request monitoring data from one or more vehicles **101**A-N via the network **132**. The request may specify a time, location, and/or vehicle identifier(s) of interest. For example, the intake module **1042** may issue a request for monitoring data pertaining to a collision to one or more vehicles **101**A-N. The request may specify a time and/or location of the collision and may identify vehicles involved in the collision. The time and/or location may be specified as ranges, such as a time frame before, during, and after a collision, locations within a proximity threshold of the collision location, and so on. The request may further comprise identifying information pertaining to the vehicles involved in the collision. In response to the request, the collision detection systems **101**A-N may determine whether any stored monitoring data satisfies the request and, if so, may transmit the monitoring data **272** to the monitoring service **1040**, as described above. Alternatively, or in addition, the collision detection systems **101**A-N may be configured to store the request and may be configured to transmit monitoring data **272** in response to acquiring monitoring data **272** that satisfies the request.

In some embodiments, the monitoring service **1040** may comprise a notification module **1044** configured to determine whether received monitoring data **272** indicates that a collision has occurred (or is predicted to occur). The notification module **1044** may be configured to transmit one or more collision notifications **1045** and/or collision alerts **1047**. The notification module **1044** may be configured to coordinate with an emergency response entity **1060** in response to receiving monitoring data **272** indicative of a collision; the monitoring service **1040** may transmit a collision notification **1045** to an emergency response entity **1060** or other entity (e.g., public safety entity, traffic control entity, or the like). Transmitting the collision notification **1045** may comprise extracting collision information from the monitoring data **272**, which, as described above, may include, but is not limited to: a collision detection model, sensor data, kinematic information pertaining to the collision (e.g., determine impact velocity, estimate forces involved in the collision, and so on), estimates of the resting positions of the vehicles involved in the collision (and/or the vehicle occupants), location of the collision, time of the collision, number of vehicles involved in the collision, estimated severity of the collision, and so on. Transmitting the collision notification **1045** may comprise determining identifying the emergency response entity **1060** based upon location of the collision, translating and/or converting the monitoring data **272** into a suitable format for the emergency response entity **1060**, and so on.

The notification module **1044** may be further configured to provide collision alerts **1047** to one or more of the collision detection systems **101**A-N. Collision alerts **1047** may be transmitted to vehicles **102**A-N within a proximity of a collision and/or vehicles **102**A-N that may be traveling toward a collision. A collision alert **1047** may comprise information pertaining to the location and/or time of the collision, estimates of the severity of the collision, and so on, as described above. The collision detection systems **101**A-N may alert the vehicle operator to the collision and/or recommend an alternative route to a navigation system of the vehicle **102**A-N in response to receiving the collision alert **1047**.

The notification module **1044** may be further configured to transmit collision notifications **1045** and/or collision alerts **1047** to other objects and/or entities, such as pedestrians, mobile communication devices, and the like. For example, in some embodiments, the notification module **1044** may be configured to broadcast a collision alert **1047** to mobile communication devices (of one or more pedestrians and/or vehicle operators) via one or more wireless transmitters (e.g., cellular data transceivers) in the network **132**. The collision alert **1047** may indicate that a collision has occurred and/or is predicted to occur, as described above.

In another example, the monitoring service **1040** may respond to requests from the emergency services entity **1060**. For example, the emergency service entity **1060** may request data pertaining to a particular vehicle, such as a vehicle that is subject to an AMBER ALERT™. The monitoring service **1040** may request data pertaining to the vehicle from the vehicles **101**A-N. In response to receiving relevant monitoring data **272**, the monitoring service **1040** may transmit the monitoring data **272** to the emergency services entity **1060**. Transmitting the monitoring data **272** to the emergency service entity **1060** may comprise translating and/or converting the monitoring data **272** into a suitable format, as described above. The monitoring service **1040** may provide the monitoring data **272** as it is received (e.g., in "real-time") and/or may provide monitoring data stored on the persistent storage **1054**.

As described above, the intake module **1042** may be configured to store and/or index monitoring data **1072**A-N in the persistent storage **1054**. The monitoring data **1072**A-N may be retained on the persistent storage **1054** for a pre-determined time period. In some embodiments, monitoring data **1072**A-N pertaining to collisions (and/or potential collisions) may be retained, whereas other monitoring data **1072**A-N may be removed after a pre-determined time period (and/or moved to longer-term storage, such as tape backup or the like).

The monitoring service **1040** may be further configured to respond to requests **1081** for monitoring data from one or more requesting entities **1080**A-N. A requesting entity **1080**A-N may include, but is not limited to: an individual, a company (e.g., an insurance company), an investigative entity (e.g., police department), an adjudicative entity (e.g., a court, mediator, etc.), or the like. A request for monitoring data **1081** may be generated by a computing device, such as a notebook, laptop, tablet, smart phone, or the like, and may comprise one or more request criteria, such as a time, location, vehicle identifier(s) or the like.

The monitoring service **1040** may comprise a query module **1046** configured to respond to requests **1081** for monitoring data. The query module **1046** may extract request criteria from a request, and may determine whether the persistent storage comprises monitoring data **1072**A-N corresponding to the request (e.g., monitoring data pertaining to a time and/or location specified in the request **1081**). The determination may be made by comparing criteria of the request **1081** to the entries **1072**A-N and/or the indexing entries **1073**A-N. The query module **1046** may generate a response **1083**, which may comprise portions of the conforming monitoring data **1072**A-N. Generating the response **1083** may comprise converting and/or translating the monitoring data **1072**A-N (and/or portions thereof), as described above. For example, a requesting entity **1080**A-N may be the owner of a vehicle involved in a collision, and the request **1081** may comprise a request for monitoring data **1072**A-N pertaining to the time and/or location of the collision. The monitoring data **1072**A-N may be used reconstruct the peri-collisional circumstances in order to, inter alia, determine fault and/or insurance coverage for the collision.

In some embodiments, the monitoring service **1040** may provide access to the monitoring entries **1072**A-N in exchange for consideration, such as a payment, bid, reciprocal data access (e.g., access to monitoring data **272** of one or more vehicle(s) of the requesting entity **1080**A-N), or the like. The request **1081** may, therefore, comprise an offer and/or payment. The query module **1046** may determine whether the offer of the request **1081** is sufficient (e.g., complies with one or more policy rules). The query module **1046** may reject the request, which may comprise transmitting an indication that the request was not fulfilled, transmitting a counteroffer to the requesting entity **1080**A-N, or the like. Accepting the request may comprise transferring a payment (or other exchange) and transmitting a response **1083** to the requesting entity **1080**A-N, as described above. Alternatively, or in addition, the query module **1046** may be configured to generate a bill and/or invoice in response to providing access to one or more of the monitoring entries **1072**A-N. The bill and/or invoice may be generated based upon a pre-determined price list, which may be provided to the requesting entity **1080**A-N. The bill and/or invoice may be transmitted to the requesting entity **1080**A-N via the network **132**.

In some embodiments, the query module **1046** is configured to determine whether the requesting entity **1080**A-N is authorized to access the stored monitoring data (monitoring entries **1072**A-N), which may comprise authenticating the requesting entity **1080**A-N by, inter alia, authenticating the request **1081**, authenticating a credential provided by the requesting entity **1080**A-N, or the like. Authorization to access the stored monitoring entries **1072**A-N may be based upon one or more access control data structures **1074** maintained by the monitoring service **1040**. The access control data structures **1074** may comprise any suitable data structure for determining access rights, such as access control lists (ACL), role-based access, group rights, or the like. For example, a requesting entity **1080**A may subscribe to the monitoring service **1040** and, as such, may be identified as an "authorized entity" in one or more access control data structures **1074**. The monitoring service **1040** may allow the requesting entity **1080**A to access the monitoring entries **1072**A-N in response to authenticating the identity of the requesting entity **1080**A and/or verifying that the requesting entity **1080**A is included in one or more of the access control data structures **1074**.

FIG. **11** is a flow diagram of one embodiment of a method **1100** for providing a monitoring service. At step **1110** the method **1100** starts and is initialized, as described above.

Step **1120** may comprise receiving monitoring data **272** from one or more collision detection systems **101**A-N. The monitoring data **272** may be received in response to a request from the monitoring service **1040**, in response to a collision detection system **101**A-N transmitting monitoring data **272** during operation and/or at a particular interval and/or in response to a particular event (e.g., a collision, the collision detection system **101**A-N establishing communication with the network **132**, or the like), and/or in response to a computing device **1037** accessing stored monitoring data **272**, as described above.

Step **1120** may further comprise offering and/or providing consideration in exchange for the monitoring data **272**. The exchange may comprise providing a payment for the monitoring data **272**, bidding for access to the monitoring data **272**, providing reciprocal access, or the like, as described above.

Step **1130** may comprise storing the monitoring data on a persistent storage **1054**. Step **1130** may further comprise indexing the monitoring data by one or more indexing criteria, which may include, but is not limited to: time, location, vehicle identifiers, or the like. Accordingly, step **1130** may comprise extracting and/or deriving indexing criteria **1130** from the monitoring data **272** received at step **1120**, as described above. In some embodiments, step **1130** further comprises translating and/or converting the monitoring data **272** (e.g., translating the monitoring data **272** from a frame of reference of a particular vehicle **102**A-N into an absolute frame of reference, or the like).

The monitoring data **272** received at step **1120** may indicate that a collision has occurred and/or is predicted to occur. Accordingly, step **1130** may further comprise generating and/or transmitting a collision notification **1045** to an emergency services entity **1060**. As described above, the collision notification **1045** may identify the location and/or time of the collision, may include estimates of collision forces (and resulting collision impact forces and/or vehicle kinematics), and so on. Step **1130** may further comprise generating and/or transmitting one or more collision alerts to one or more vehicles **102**A-N, mobile communication devices, pedestrians, emergency services entities, or the like, as described above. The method **1100** ends at step **1140**.

FIG. **12** is a flow diagram of another embodiment of a method **1200** for providing a monitoring service. At step **1210** the method **1200** starts and is initialized, as described above.

Step **1220** may comprise receiving a request for monitoring data (e.g., data of one or more monitoring entries **1072**A-N). The request of step **1220** may be received from a requesting entity **1080**A-N by way of a network **132**. The request may include request criteria, such as a time, location, vehicle identifier(s) or the like, as described above. The request may further comprise an offer of consideration in exchange for fulfilling the request. The offer may include, but is not limited to: a payment, bid, reciprocal data access, or the like. Step **1220** may comprise determining whether the offer is acceptable and, if not, rejecting the offer and/or generating and/or transmitting an offer (or counter offer) to the requesting entity **1080**A-N. Step **1220** may further comprise authenticating the requesting entity and/or determining whether the requesting entity is authorized to access the stored monitoring entries **1072**A-N, as described above (e.g., based upon one or more access control data structures **1074**).

Step **1230** may comprise identifying monitoring data that conforms to the request (e.g., monitoring data associated with a time, location, and/or vehicle identifier specified in the request). As such, step **1230** may comprise identifying one or more monitoring entries **1072**A-N that satisfy the request criteria, which may include comparing criteria of the request to the entries **1072**A-N and/or index entries **1073**A-N, as described above. For example, step **1230** may comprise identifying monitoring entries **1072**A-N associated with a time specified in the request, associated with a location specified in the request, associated with a vehicle identifier specified in the request, and so on.

Step **1240** may comprise generating and/or transmitting a response **1083** to the requesting entity **1080**A-N. Step **1240** may comprise translating and/or converting data of the monitoring entries **1072**A-N identified at step **1230**, as described above. The method **1200** ends at step **1250**.

This disclosure has been made with reference to various exemplary embodiments. However, those skilled in the art will recognize that changes and modifications may be made to the exemplary embodiments without departing from the scope of the present disclosure. For example, various operational steps, as well as components for carrying out operational steps, may be implemented in alternate ways depending upon the particular application or in consideration of any number of cost functions associated with the operation of the system (e.g., one or more of the steps may be deleted, modified, or combined with other steps). Therefore, this disclosure is to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope thereof. Likewise, benefits, other advantages, and solutions to problems have been described above with regard to various embodiments. However, benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, a required, or an essential feature or element. As used herein, the terms "comprises," "comprising," and any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, a method, an article, or an apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, system, article, or apparatus. Also, as used herein, the terms "coupled," "coupling," and any other variation thereof are intended to cover a physical connection, an electrical connection, a magnetic connection, an optical connection, a communicative connection, a functional connection, and/or any other connection.

Additionally, as will be appreciated by one of ordinary skill in the art, principles of the present disclosure may be reflected in a computer program product on a machine-readable storage medium having machine-readable program code means embodied in the storage medium. Any tangible, non-transitory machine-readable storage medium may be utilized, including magnetic storage devices (hard disks, floppy disks, and the like), optical storage devices (CD-ROMs, DVDs, Blu-Ray discs, and the like), flash memory, and/or the like. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions that execute on the computer or other programmable data processing apparatus create means for implementing the functions specified. These computer program instructions may also be stored in a machine-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the machine-readable memory produce an article of manufacture, including implementing means that implement the function specified. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process, such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified.

While the principles of this disclosure have been shown in various embodiments, many modifications of structure, arrangements, proportions, elements, materials, and components that are particularly adapted for a specific environment and operating requirements may be used without departing from the principles and scope of this disclosure. These and other changes or modifications are intended to be included within the scope of the present disclosure.

What is claimed is:

1. A method, comprising:

generating a request at a first land vehicle to configure a sensing system of a second land vehicle to acquire sensor data at the second land vehicle by use of one or more sensors of the sensing system of the second land vehicle; and

generating a collision detection model using sensor data acquired by use of the one or more sensors of the sensing system of the second land vehicle.

2. The method of claim **1**, further comprising forming a multistatic sensor comprising at least a portion of a sensing system of the first land vehicle and at least a portion of the sensing system of the second land vehicle.

3. The method of claim **2**, wherein the multistatic sensor comprises one or more detection signal emitters, including a detection signal emitter of the first land vehicle.

4. The method of claim **2**, wherein the multistatic sensor comprises one or more receivers, including a receiver of the first land vehicle.

5. The method of claim **2**, wherein forming the multistatic sensor comprises configuring the sensing system of the first land vehicle to receive a detection signal emitted by the sensing system of the second land vehicle.

6. The method of claim **2**, wherein forming the multistatic sensor comprises configuring the sensing system of the first land vehicle to emit a sensing signal configured to be detected by a receiver of the second land vehicle.

7. The method of claim **6**, further comprising using sensor data acquired by use of the sensing system of the second land vehicle in response to the sensing signal emitted by the sensing system of the first land vehicle to generate the collision detection model.

8. The method of claim **2**, wherein forming the multistatic sensor comprises steering a sensing signal to a pre-determined area.

9. The method of claim 2, wherein forming the multistatic sensor comprises beamforming the sensing system of the first land vehicle and the sensing system of the second land vehicle.

10. The method of claim 9, wherein beamforming comprises directing a detection signal of the multistatic radar in a pre-determined direction.

11. The method of claim 9, wherein beamforming comprises varying a phase of a detection signal emitted by one of the sensing system of the first land vehicle and the sensing system of the second land vehicle.

12. The method of claim 9, wherein beamforming comprises varying an amplitude of a detection signal emitted by one of the sensing system of the first land vehicle and the sensing system of the second land vehicle.

13. The method of claim 2, wherein forming the multistatic sensor comprises forming a multistatic radar comprising at least a portion of a radar sensing system of the first land vehicle and at least a portion of a radar sensing system of the second land vehicle.

14. The method of claim 2, wherein forming the multistatic sensor comprises forming a multistatic radar comprising a plurality of radar receivers, including a radar receiver of the first land vehicle.

15. The method of claim 2, wherein forming the multistatic sensor comprises forming a multistatic radar comprising a plurality of radar transmitters, including a transmitter receiver of the first land vehicle.

16. The method of claim 2, wherein forming the multistatic sensor comprises forming a bistatic radar comprising a radar transmitter of the first land vehicle and a radar receiver of the second land vehicle.

17. The method of claim 2, wherein forming the multistatic sensor comprises forming a bistatic radar comprising a radar receiver of the first land vehicle and a radar transmitter of the second land vehicle.

18. The method of claim 2, wherein forming the multistatic sensor comprises forming a phased array comprising at least a portion of the sensing system of the first land vehicle and at least a portion of the sensing system of the second land vehicle.

19. The method of claim 17, further comprising steering the phased array in a pre-determined direction.

20. The method of claim 2, further comprising:

acquiring auxiliary data pertaining to the second land vehicle; and

using the acquired auxiliary data to form the multistatic sensor.

21. The method of claim 20, wherein the acquired auxiliary data comprises one of acceleration, velocity, position, and orientation of the second land vehicle.

22. The method of claim 20, further comprising requesting auxiliary data from the second land vehicle.

23. A collision detection system, comprising:

a coordination module of a first land vehicle configured to generate a request to configure a sensing system of a second land vehicle to acquire sensor data at the second land vehicle by use of one or more sensors of the sensing system of the second land vehicle; and

a processing module configured to generate a collision detection model using sensor data acquired by use of the one or more sensors of the sensing system of the second land vehicle.

24. The collision detection system of claim 23, further comprising a communication module configured to transmit the request to the second land vehicle.

25. The collision detection system of claim 23, further comprising a communication module configured to receive sensor data acquired by use of the sensing system of the second land vehicle, wherein the processing module is configured to generate the collision detection model using the sensor data acquired by use of the sensing system of the second land vehicle and the sensor data acquired by use of a sensing system of the first land vehicle.

26. The collision detection system of claim 23, wherein the coordination module is configured to select the second land vehicle based at least in part on at least one of position of the second land vehicle, orientation of the second land vehicle, sensor capability of the second land vehicle, the position of the second land vehicle relative to a specified region, the position of the second land vehicle relative to a specified object, the orientation of the second land vehicle relative to the specified region, and the orientation of the second land vehicle relative to the specified object.

27. The collision detection system of claim 23, wherein the request identifies a region, and wherein the sensing system of the second land vehicle directs a detection signal to the identified region in response to the request.

28. The collision detection system of claim 27, wherein the detection signal is configured to be detected by a receiver of a sensing system of the first land vehicle.

29. The collision detection system of claim 23, wherein the request identifies an object, and wherein the sensing system of the second land vehicle directs a detection signal to the identified object in response to the request.

30. The collision detection system of claim 29, wherein the detection signal is configured to be detected by a receiver of a sensing system of the first land vehicle.

31. The collision detection system of claim 23, wherein the coordination module is configured to generate the request in response to determining that kinematic information pertaining to an object does not satisfy a threshold.

32. The collision detection system of claim 31, wherein determining that the kinematic information pertaining to the object does not satisfy the threshold comprises determining that a signal-to-noise ratio of sensor data pertaining to the object does not satisfy the threshold.

33. The collision detection system of claim 31, wherein determining that the kinematic information pertaining to the object does not satisfy the threshold comprises determining that an orientation of the sensing system of the first land vehicle prevents determining one or more kinematic characteristics of the object.

34. A machine-readable storage medium comprising instructions configured to cause a collision detection system to perform a method, comprising:

generating a request at a first land vehicle to configure a sensing system of a second land vehicle to acquire sensor data at the second land vehicle by use of one or more sensors of the sensing system of the second land vehicle; and

generating a collision detection model using sensor data acquired by use of the one or more sensors of the sensing system of the second land vehicle.

35. The machine-readable storage medium of claim 34, the method further comprising forming a multistatic sensor comprising at least a portion of a sensing system of the first land vehicle and at least a portion of the sensing system of the second land vehicle.

36. The machine-readable storage medium of claim 35, wherein the multistatic sensor comprises one or more detection signal emitters, including a detection signal emitter of the first land vehicle.

37. The machine-readable storage medium of claim **35**, the method further comprising:

acquiring auxiliary data pertaining to the second land vehicle; and

using the acquired auxiliary data to form the multistatic sensor.

38. The machine-readable storage medium of claim **34**, the method further comprising generating the request in response to determining that an object is inside of a detection envelope of a sensing system of the second land vehicle.

39. The machine-readable storage medium of claim **34**, wherein the request comprises a payment offer.

40. The machine-readable storage medium of claim **34**, wherein the request comprises an offer of access to the collision detection model.

41. The machine-readable storage medium of claim **34**, wherein the request comprises an offer of access to sensor data acquired by use of the sensing system of the first land vehicle.

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